Technical Report 1124

Intelligent Tutoring System for Teaching Battlefield Command Reasoning Skills – Phase I Final Report

Eric A. Domeshek
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March 2002

United States Army Research Institute for the Behavioral and Social Sciences

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This report documents Phase I efforts and Phase II plans to develop an Intelligent Tutoring System for Teaching Battlefield Command Reasoning Skills.

14. ABSTRACT *(Maximum 200 words)*:

Report developed under a Small Business Innovation Research Program 2000.2 contract for topic OSD00-CR02. The research reported here aimed at the design of a Socratic Intelligent Tutoring System (ITS) for high-level battlefield command reasoning skills. The ultimate goal of this research is to develop new ITS techniques and technology for teaching skills that cannot be taught as simple methods and procedures to be followed. Achieving expert levels of proficiency in high-level command reasoning skills—whether for battlefield commanders or for executives in industry—requires extensive practice, coaching, and feedback. Learners must be given a chance to drill on detailed and situation-specific knowledge, as well as high-level thinking habits and skills applicable across diverse situations. We studied exemplary command reasoning mentoring by observing tutoring sessions centered on Tactical Decision Games (TDGs). We analyzed those sessions to produce a first draft general model of tutoring actions. We also built a limited proof-of-concept prototype that exhibited many of the key behaviors identified. Taken together, the conduct and products of our Phase I work, along with our proven strong team of collaborators, position us well to carry through on the ambitious work plan outlined here for Phase II.

15. SUBJECT TERMS
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Personnel Performance and Training Technology

FOREWORD

Improvements in Army training and evaluation are an enduring concern of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI). A related concern addressed in this effort is that military officers may have insufficient opportunity to apply their battle command reasoning skills in realistic battle command situations. One way to provide sufficient opportunity is through an intelligent tutoring system (ITS) for training battlefield command reasoning skills.

This Phase I Small Business Innovation Research Program (SBIR) effort targeted the design and limited demonstration of a Socratic ITS for high-level battlefield command reasoning skills. The research goal was to develop innovative training methods for conceptual skills, particularly new ITS techniques and technology for teaching skills that cannot be taught as simple methods and procedures to be followed. The product goal was an ITS for training battlefield command reasoning skills that could be hosted on an interactive web site. Overall, the objectives for developing such an ITS prototype include: anytime, anywhere tutoring; deliberate practice opportunities; standardized instructional procedures; and at least a partial answer to the growing problem of limited expert human tutors.

This research was part of ARI's Future Battlefield Conditions (FBC) team efforts to enhance soldier preparedness through development of training and evaluation methods to meet future battlefield conditions. This report represents efforts for Work Package 211, Techniques and Tools for Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) Training of Future Brigade Combat Team Commanders and Staffs (FUTURETRAIN). Results of this effort were briefed to the Director of Bio-Systems, Office of the Director, Defense Research and Engineering. As a result of the Phase I success, the Phase II effort was awarded and an ITS for conceptual skill training should be available for commercial application by September 2003.

Michael G. Rumsey

MICHAEL G. RUMSEY
Acting Technical Director

ACKNOWLEDGEMENTS

This report reflects work performed under a Small Business Innovation Research Program 2000.2 contract for topic OSD00-CR02. The project aimed at design of a Socratic Intelligent Tutoring System (ITS) for high-level battlefield command reasoning skills. What is reported here reflects the efforts of a large team.

I would like to thank our contract monitors at the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) Fort Knox Field Unit. Dr. James Lussier had the vision that led to this line of research. Dr. Carl Lickteig was immensely helpful in managing all of the details of the project. Dr. Ted Schlechter was also quite supportive of our work.

Our subject matter experts, U.S. Marine Major John Schmitt (Ret.) and Brigadier General Keith Holcomb (Ret.) were both central to the development of this project. We quite literally could not have done it without them. Their tactical expertise, combined with their enthusiasm for and experience with the Tactical Decision Games (TDG) format (including development of the electronic distributed version of TDGs) was invaluable. Equally critical was their ability to recruit active-duty Marine Captains to serve as subjects of tutoring observations. It is a tribute to their reputations and recognized skills that they were easily able to provide as many volunteers as we could use. I would also like to thank the four Marine Captains who volunteered as subjects for the Phase I observations.

Our colleagues at Klein Associates, Inc., Karol Ross, and Rob Hutton were also very helpful in designing and carrying out the research reported here. They contributed most heavily in the instructional observations, helping to develop the format and schedule, serving as observers of the actual sessions, preparing session transcripts, and providing analysis of the results.

Special thanks to Dick Stottler of Stottler Henke Associates, Inc. (SHAI) for conceiving this project, setting it up, and providing direction. And last, but certainly not least, I gratefully acknowledge the efforts of Eli Holman who implemented the Phase I prototype system that is described in this report.

PHASE I FINAL REPORT ON AN INTELLIGENT TUTORING SYSTEM FOR TEACHING BATTLEFIELD COMMAND REASONING SKILLS

EXECUTIVE SUMMARY

Research Requirement:

Under extreme stress, time pressure, and uncertainty, commanders must assess complex, ambiguous tactical situations, develop and prioritize goals, and pursue these goals by issuing orders, reports, and requests that consider the situation, own assets and capabilities, and the assets, capabilities, and intentions of the enemy. High performance decision-making requires the commander to apply detailed and situation-specific knowledge as well as high-level thinking habits and skills that are applicable across diverse tactical situations. These skills include *modeling a thinking enemy*, *using all available assets*, and *considering how the commander's fight fits into the bigger picture from friendly and enemy perspectives*.

These reasoning skills cannot be taught simply as methods and procedures to be followed. Although guidelines can help commanders achieve baseline levels of performance, achieving an expert level of proficiency requires:

- **Extensive practice** of command reasoning skills in a variety of situations to acquire and reinforce skills until they can be applied flexibly and automatically. This experience can include a combination of actual combat, live training exercises, computer-based and paper-based simulations, and mental exercises.
- **Coaching and feedback** from instructors to identify strengths and weaknesses in performance, encourage reflection, stimulate the student's thought processes, and enhance the student's reasoning capabilities.

Coaching and feedback are typically provided by expert instructors during dialogs with students. An example of this type of instruction includes Think Like a Commander (TLAC) materials (U.S. Army Research Institute, 2001). These TLAC materials are currently used in officer courses at Fort Leavenworth and Fort Knox. Another example is Tactical Decision Games (TDGs) (e.g., Schmitt, 1994). In both these forms of training, tactical scenarios are presented to learners who must then reach conclusions and make decisions. If the learner fails to take an applicable theme into account, the instructor asks the student questions, at first indirect, to encourage the student to reflect upon his or her thinking about a theme.

An inherent limitation of mentored instruction is that the expert mentors are an expensive limited resource that is infrequently available; when available their attention must often be shared among too many learners for truly effective personalized interaction. Classroom instruction, such as Army officer training, adds the constraint that instruction is only accessible to learners who can attend the course on site, requiring significant time and travel costs as well as scheduling difficulties. Automated, computer-based training can provide instruction “any time, any place.” However, the types of expert coaching and mentoring required to teach these command reasoning skills require far more sophisticated reasoning than is possible with current computer-based

training (CBT) and web-based training (WBT) technologies that typically assess learners based on simple multiple-choice and fill-in-the-blank questions.

Intelligent Tutoring Systems (ITSs) are computer-based training systems that mimic human instructors to provide automated, one-on-one instruction. Intelligent Tutoring Systems encode subject matter and instructional expertise to assess each learner's performance, knowledge, and skills to provide individualized learning experiences, adapted to each learner's skills, background, and learning preferences. Most ITSs provide a simulation or problem-solving user interface that enables learners to solve problems or pursue goals by entering a sequence of actions or decisions selected from a wide range of possible choices. The ITS applies subject matter expertise to evaluate these actions and decisions to assess the learner's knowledge and skills and then select and deliver appropriate instructional interventions.

However, no ITS system developed to date supports a domain nearly as complex as battlefield command which requires sophisticated reasoning about a large number of goals, potential plans, variables, and constraints. Evaluation of each learner's solution is extremely challenging because there is no single "correct" solution to each scenario. As Gen. George S. Patton wrote, "There is no approved solution to any tactical situation." Thus, developing an ITS for teaching battlefield command reasoning skills will require "pushing the envelope" in ITS technology along a number of dimensions, such as:

- Representing solutions and their rationale to complex battlefield command problems,
- Assessing the learner's reasoning skills by comparing each learner's solution with multiple expert solutions and their rationale, and
- Implementing learner-mentor interactions that enhance high-level thinking habits, based on an assessment of each learner's reasoning, as well as knowledge structures that represent each expert's reasoning.

Procedure:

During Phase I, our objectives were to:

1. Identify the kinds of **tactical analysis knowledge** that should be represented by the system to support the evaluation of learner solutions to tactical scenarios, in order to refine the system's student model.

2. Explore and evaluate candidate **interaction techniques** that can achieve the types of instructional goals currently achieved in learner/mentor interactions with expert human instructors.

3. Identify the types of **automated tutoring strategies** needed to select and generate effective instructional interventions based on a student model.

4. Develop methods for **authoring ITS scenarios** by entering good and bad sets of decisions and rationale, and then annotating these solutions with skills that are demonstrated (positively or negatively) by each solution.

5. Develop a limited, proof-of-concept **software prototype** that illustrates key ideas related to learner/mentor interaction methods, tactical analysis knowledge representation, and interactive tutoring strategies.

Our core activities during the Phase I effort included:

a. Study of prior work related to the project goals (e.g., reasoning skills training, ITS techniques and Socratic Tutoring, and the existing Think Like a Commander course).

b. Conduct, observation, and analysis of a series of Tactical Decision Game tutoring sessions between active-duty Marine Captains and acknowledged tactical (and tutoring) experts.

c. Design and construction of a proof-of-concept Command Mentoring Intelligent Tutoring System (ComMentor) prototype based on a single TDG scenario covered in multiple tutoring sessions.

With respect to our original objectives, activities 'a' and 'b' directly addressed objectives 1, 2, and 3. Our early work on activity 'a' helped frame the problem. The extensive observations and analysis in activity 'b' ended up forming the primary basis for most of our work; identification of knowledge form and content, interaction techniques, and tutoring strategies all fed forward into later objectives. Activity 'c' directly addressed objectives 4 and 5. Our work on objective 4 was not only a necessary precondition to success on objective 5, but forms the groundwork for Phase II work on task-specific authoring tools. Likewise the prototype produced for objective 5 not only demonstrates the feasibility of our ideas, but also serves as a design base and source of lessons learned for our proposed further system development during Phase II.

Findings:

Our major Phase I accomplishments fall into four categories:

1. Developing a deep understanding of the battlefield command domain, and of existing techniques for training battlefield command reasoning skills (see "Findings Based on ARI Direction and Materials").

2. Observing, analyzing, and classifying Socratic tutoring techniques for battlefield command reasoning skills (see "Findings Based on TDG Observations and Analysis").

3. Designing and building a limited proof-of-concept prototype system called ComMentor that demonstrates an automated implementation of many tutoring techniques observed and cataloged above (see "PHASE I PROTOTYPE SYSTEM").

4. Developing a system design and work plan for the Phase II implementation of a full ComMentor prototype (see "PHASE II SYSTEM DESIGN" and "FUTURE WORK").

Utilization of Findings:

In this Phase I project, we have developed and documented a detailed understanding of how expert human tutors Socratically guide junior commanders through training scenarios in order to drill and improve their battlefield command reasoning skills. Further, we have demonstrated, through construction of a limited proof-of-concept prototype, that many of the observed tutoring behaviors can be duplicated by an ITS. Finally, we have developed a detailed plan for how to proceed with Phase II development of a complete, evaluable, ComMentor prototype. As the Phase II proposal was awarded, the findings will be used to complete development of a prototype ITS for battle command reasoning skills by September 2003.

PHASE I FINAL REPORT ON AN INTELLIGENT TUTORING SYSTEM FOR TEACHING BATTLEFIELD COMMAND REASONING SKILLS

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Introduction

Overview of Problem and Solution

Under extreme stress, time pressure, and uncertainty, commanders must assess complex, ambiguous tactical situations, develop and prioritize goals, and pursue these goals by issuing orders, reports, and requests that consider the situation, own assets and capabilities, and the assets, capabilities, and intentions of the enemy. High performance decision-making requires the commander to apply detailed and situation-specific knowledge as well as high-level thinking habits and skills that are applicable across diverse tactical situations. These skills include *modeling a thinking enemy*, *using all available assets*, and *considering how the commander's fight fits into the bigger picture from friendly and enemy perspectives*.

Problem. These reasoning skills cannot be taught simply as methods and procedures to be followed. Although guidelines can help commanders achieve baseline levels of performance, achieving an expert level of proficiency requires:

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Opportunity. We propose to proceed with development of a Command Mentoring Intelligent Tutoring System (ComMentor) based on the observations and designs generated during our Phase I effort. As demonstrated by our Phase I prototype, ComMentor will present TDG scenarios to the learner, and then manage a Socratic dialog discussing the scenarios with the learner. The system will interpret and evaluate the learner's solution, and then interact with the learner to stimulate his or her reasoning skills and refine its assessment of the learner's strengths and weaknesses. A combination of artificial intelligence and intelligent tutoring system technologies provides enabling technologies for this system, such as:

- **Scenario-Based Instruction** – Stottler Henke Associates, Inc. (SHAI) has pursued scenario-based (or case-based) approaches in numerous tutoring systems in which the system's knowledge base contains a library of problems, or scenarios, to present to the learner. Each scenario has associated pattern-recognizers that evaluate the learner's decisions and actions and outcomes of the simulation to estimate the learner's mastery (or lack of mastery) of knowledge or skills. These mastery level estimates then provide the basis for selecting instructional interventions (e.g., lessons, feedback, hints, questions, and stories) that prompt the learner to reflect on his or her thinking and search for and

consider alternatives. This scenario-based approach differs from expert system/model-tracing approaches that generate problems, solve them, and then compare these automatically generated solutions with those of the learner. Compared to model tracing tutoring systems, scenario-based tutoring systems can teach skills in more complex domains because the system applies *scenario-specific knowledge* to interpret each student's actions. Since the range of likely problems and plausible solutions is much narrower for a single scenario than for all possible scenarios, scenario-specific knowledge can be used with relatively simple pattern recognition algorithms to interpret and assess likely student actions accurately within a given scenario, even in complex domains.

- **Application-Specific Scenario Authoring Tools** – Any knowledge-based software system is only as powerful and up-to-date as the set of concepts, rules, cases, and other objects in its knowledge base. In large, complex, and continually evolving domains, such as battlefield command, practical development and maintenance of a high-performance knowledge base requires the ability to capture most of the knowledge directly from subject matter experts, without programming. Some tutoring systems provide "generic authoring tools" that present a standard user interface by which the subject matter expert must enter knowledge into the tutoring system. In many situations, however, subject matter experts can enter scenario knowledge much more quickly and easily by using knowledge representations and knowledge editors that are targeted to a specific application domain, such as military tactical decision-making. For example, our Acoustic Analysis Intelligent Tutoring System (AAITS) under development for the U.S. Navy captures the reasoning processes of undersea acoustic analysis experts by enabling them to annotate frequency-analyzed acoustic data images (LOFARGRAMs) with features, sources, and final classifications using a point-and-click user interface. Thus, AAITS enables experts to maintain the tutoring system's knowledge base of scenario-based problems and solutions by carrying out a familiar analysis activity in a natural and intuitive way.
- **Rationale Capture** – When evaluating each learner's solutions, it's necessary to understand the learner's reasoning behind his or her decisions. Using scenario-based instruction, it is possible to capture the reasoning (or rationale) of experts for each scenario, ask the learner questions that elicit his or her reasoning, and compare this reasoning with those of experts. The rationale underlying expert solutions can also be used to stimulate the learner's reflection and reasoning by identifying issues considered by the expert, and then asking the learner questions that lead the learner to think about those issues as well.
- **Multi-Modal, Mixed-Initiative Conversational Interaction** – Our Phase I prototype illustrates the interaction of graphical and textual input and output modalities; in Phase II we intend to explore the possibility of supporting speech input and output as well (an area of research under current development at SHAI's Seattle office in the Navy funded TALK project). With regard to interaction initiative, while it is true that Socratic tutoring puts most control into the hands of the instructor, that control is highly conditioned on the actions of the student; further, the instructor must always be ready to respond to a direct query or topic shift by the student (though clearly sometimes the right response is to dismiss or defer such student initiatives). Again, SHAI has already begun to develop the technology for control of mixed-initiative tutorial dialogs.

At SHAI, we have a team uniquely qualified to extend and integrate the technologies identified above. During this proposed project, we plan to draw upon our past experiences, and those of other researchers in these areas.

Solution. The ComMentor's assessment of the student's understanding and intentions will be based on several subsystems, initially conceived as an analysis pipeline that feeds its outputs back to the user interface, but actually implemented in Phase I as an executive making calls on two subordinate modules (see Figure 1 and Figure 2 for abstracted architecture diagrams reflecting the Phase I design and actual implementation):

1. A Graphic Input Analyzer (GIA) that extracts situation descriptions from icon placements, area highlights, and path indications the student draws on the scenario map;

2. A Text Input Analyzer (TIA) that attempts to categorize the student's typed input into one of an expected set of utterances (e.g., orders, reports, requests, questions, answers, or assertions). Those utterance expectations are modulated by the state of the tutorial interaction (e.g., the question or statement the tutor just made) and the prior student assessment.

3. A Domain Inference Module (DIM) that applies rules from a domain knowledge-base to answer a range of relatively concrete questions, and derive higher level situation descriptions from the outputs of the GIA and TIA.

4. A Case Assessment Module (CAM) that uses the results of input analysis and inference to retrieve situation-specific cases (prototypical good and bad solutions) that serve as hypotheses about student understanding and intentions and help direct the tutoring interaction.

5. The Tutor Interaction Module (TIM) that uses the results of all the modules described above, plus its own session history, to choose a next instructor move, and bias the future analysis of the other modules.

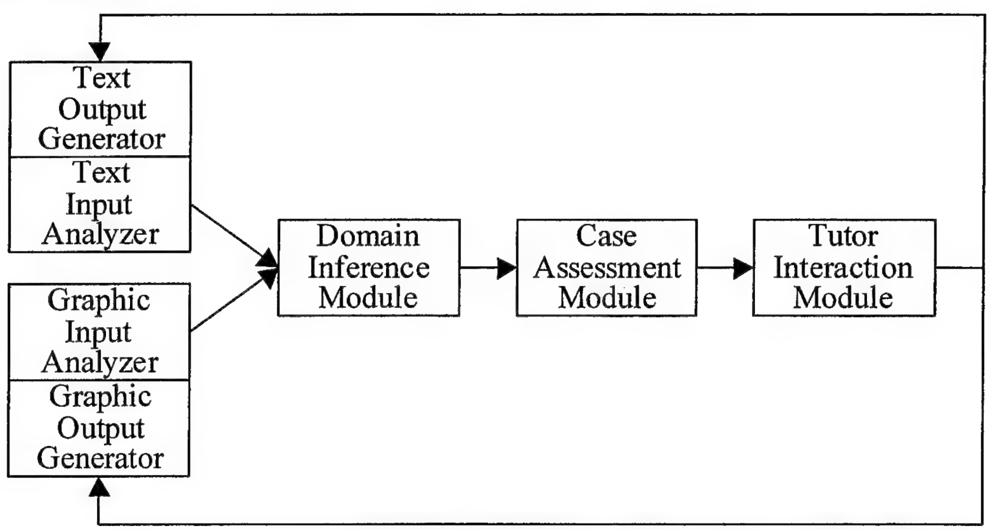

Figure 1. ComMentor Phase I Abstract System Architecture Design.

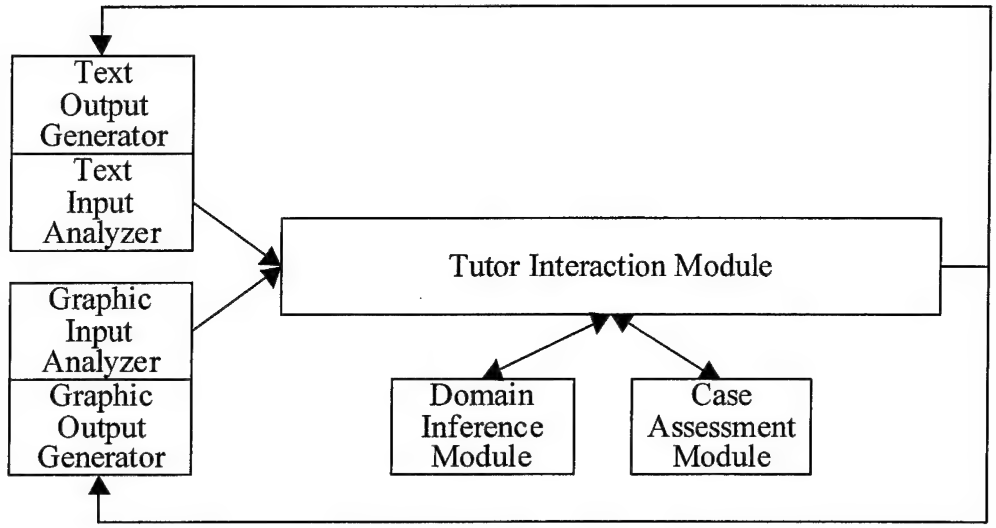

Figure 2. ComMentor Phase I Abstract System Architecture Implementation.

The CAM is a critical distinguishing component that allows ComMentor to achieve appropriate assessments of student input while limiting the amount of knowledge engineering required. A library of "good" and "bad" (fragmentary) solutions specific to a scenario is much easier for subject matter experts to provide than a complete set of general purpose analysis and assessment rules. The ComMentor will use similarities between the learner's solution and these good and bad solutions to identify strengths and weaknesses, respectively, in the learner's solution and, therefore, in the learner's underlying reasoning skills. This initial evaluation will by no means be "complete." Rather, this evaluation will result in an initial model of the learner skills employed within the scenario. This model will be refined during later interactions with the learner such as questions that probe into the learner's reasoning.

The ongoing Socratic interaction (using a combination of graphical and textual input and output) will refine the system's assessment of the learner's reasoning skills and stimulate the learner's thinking. In addition to the Phase I interaction style, in Phase II we will also explore other types of interactions such as:

- **War stories** – The tactical scenario can provide a launching point for presenting selected stories or testimonials that illustrate important, relevant lessons. For example, when the tutoring system identifies a questionable decision made by the learner, the system could identify the underlying skill or thinking habit that relates to the decision and then suggest a relevant war story to the learner that relates to the skill or decision. The key technical challenge is indexing these stories effectively so that the system can identify stories that are relevant to the student's solution or to the current state of the student-mentor dialog.
- **Speech Input/Output** – Spoken language is generally an easier and more natural medium of information exchange for people than is typed text. It is, however, a more difficult medium for computers to cope with. Nonetheless, efforts in this direction are under way, including a project at SHAI. We note that Forbus, et al. (2000) has already produced a prototype system that combines sketching and speech input to capture proposed course of action (COAs). However, feedback from military personnel

concerned with operational applications has led them to de-emphasize the speech component of their work (Forbus, personal communication, 2001).

Again, a key characteristic of our approach is our reliance on multiple recognizably good and bad scenario solutions, or solution fragments, provided by experts, to support comparison with and evaluation of the learner's solution. Use of multiple solutions increases the probability that the system can match a portion of the learner's solution with a portion of an expert's. In Phase II we will devote substantial effort towards developing authoring tools that enable domain experts to enter good and bad solutions (decisions and rationale) intuitively, using an interface that is similar to the interface used by learners. The idea is that experts could then annotate such solutions by identifying skills that are/are not demonstrated by the learner if the learner's solution matches part of the expert's good or bad solution. This scenario-specific analysis will, as sketched above, then be combined with other types of knowledge, including generic instructional strategies, scenario-specific instructional strategies, and tactical "common sense."

Benefits of our Approach

Benefits of our approach include:

- **Intelligent automated instruction of battlefield command reasoning** – As with most automated instructional systems, our approach will enable learners to learn "any time, any where," at less expense and with more scheduling flexibility. However, unlike CBT, WBT, and simpler ITSs developed to date, our approach will support sophisticated learner-mentor interactions that stimulate the learner's thinking skills for an extremely complex domain: battlefield command reasoning.
- **Feasible scenario-based knowledge acquisition** – Our scenario-based approach will enable the intuitive entry of subject matter expertise without programming, using rationale capture techniques and application-specific scenario authoring tools. By making it possible to create new scenarios quickly, it will be feasible to create a rich library of training scenarios that covers a wide range of situations and learning objectives. By making it feasible to enter many solutions for a given scenario, the system will be able to draw upon the perspectives of many different experts to evaluate each learner's solutions more accurately.
- **Adaptive, flexible instruction** – Our system will employ both generic and scenario-specific instructional strategies and principle-based instruction to support instructional interactions that are highly adaptive to the learning needs of each learner. By carefully separating the system's scenario-based tactical analysis knowledge from the system's instructional strategies, it will be possible for different instructional strategies to exploit the same tactical knowledge in many different ways, to achieve diverse instructional goals, depending upon each learner's knowledge, skill levels, and learning preferences.

Innovations

The ComMentor will be the first implementation of an ITS that supports the teaching of such complex and crucial high-level skills. Bringing together the scenario and rationale

representation, the user interfaces, and the domain knowledge will stretch the limits of what has been done in ITS, and for that matter, in artificial intelligence generally. We believe that the practical implementation of tutoring systems for large, complex domains will be enabled by avoiding "deep," expert system representations of domain concepts in favor of scenario-specific (case-based) knowledge representations that are "deep enough." Specifically, we believe strategic combination of rule based and case based reasoning, annotation of cases with rationales, and inclusion of multiple good and bad solutions and stories in the case library, together form a cluster of techniques that will enable a practical solution to a currently unsolved problem.

Relevant Methodologies

Scenario-Based Instruction

The validity of the scenario-based approach has both intuitive appeal and empirical backing. As early as 1940, Gragg (1940) argued for scenario-based instruction. By presenting scenarios that illustrate the important principles, the learner can see how principles are *applied* in operational contexts and tasks. It also defeats the well-known problem of inert knowledge first described by Whitehead, (1929) and frequently validated by other researchers. Inert knowledge is information or principles that a subject knows and can recall, but which he does not apply when the situation clearly calls for it. Scenario-based instruction (and related concepts such as example-based instruction, anchored instruction, case-based instruction, simulation-based instruction, and situated instruction) overcomes this problem by showing learners the application of principles in an operational setting and forcing them to apply them as well.

Socratic Tutoring Systems

Socratic tutoring is a recognized style of instruction, often associated with expert tutors (e.g., Glass, 1999), and known to produce effective outcomes (e.g., Rose, Moore, VanLehn & Albritton, 2000). Adopting the Socratic style is not a simplistic tutoring "trick"— it is not about syntactically transforming all tutor interventions into question form. Rather, it is best thought of as a bias towards having the student construct as much of their knowledge as possible, while also encouraging reflection and analysis. While there has been ongoing interest in automating Socratic tutoring over the last three decades, there are currently only a handful of leading laboratories with a discernable focus in this direction (e.g., Martha Evens at IIT, Art Graesser at Memphis, Johanna Moore at Edinburgh, and sometimes, Roger Schank late of Northwestern and now Cognitive Arts).

One observation to be drawn from past and current work is that most developers see unstructured language input as a useful complement to a Socratic tutoring approach. The general hypothesis is that much of the value in Socratic tutoring lies in having students work out for themselves what is going on in a given problem (thus leveraging the benefits of constructivist approaches and "self explanation") which would be somewhat short-circuited by pre-structuring lists of possible answers (or answer components) as in a menu-driven input system. For these, and other reasons related to tutoring behaviors observed in our sample sessions we chose to pursue a natural language interface in our Phase I effort.

Natural Language Input Processing

Natural Language Processing (NLP) has been an active area of artificial intelligence research since the beginning of the discipline. Much work in the field draws on well-established linguistic traditions—adopting a multi-phased analysis mechanism that starts by emphasizing syntactic parsing. However, much of the most effective work in the field has taken alternate approaches—emphasizing semantic analysis tied to some particular context of language use. This often leads to faster, more useful processing, that is robust in the face of real-world input (ungrammatical, misspelled, or telegraphic input). In fact, the dominant trend in Socratic tutoring language components is to emphasize more effective semantic analysis techniques (e.g., Brown & Burton, 1975; Glass, 1999; Wiemer-Hastings, P., Wiemer-Hastings, K., & Graesser, 1999). We note, however, that Glass (1999) has effectively critiqued the use of Latent Semantic Indexing (LSA) based approaches (as in AutoTutor) as unlikely to be very effective in domains that go far beyond general discussions of terminology and definitions, because LSA matching is primarily sensitive to overlaps in word meaning rather than to structured relationships among actions and situations so critical to scenario-based instruction. Our language interpretation approach is able to make appropriate use of the structure typically available in language.

Case-Based Situation Interpretation/Diagnosis

Our aim, in fact, is to go far beyond instruction on terms and definitions. We aim to tutor students in effective application of high-level reasoning skills in the complex domain of dynamic battlefield command. Tuning our language processing approach to extract structure descriptions is not enough; all of our student modeling and assessment must be capable of making relatively fine situational distinctions. This is where we believe the technology of case-based situation interpretation and diagnosis can be usefully applied. Our experience in building ITSs for similar domains shows that constellations of fragmentary cases can be used to effectively diagnose many student successes and failures in complex tactical scenarios. Furthermore, a case-based approach to building such recognizers tends to make it easier for domain experts to manage and maintain a tutoring system over time.

Application-Specific Authoring Tools

We hold, along with most of the ITS community, that a critical component of real-world success for ITS technology will be the ability to provide tools that let domain experts take more control of production and maintenance of training systems. We have already noted that any knowledge-based software system is only as powerful and up-to-date as the set of concepts, rules, cases, and other objects in its knowledge base. Knowledge in such systems tends to have a limited shelf-life as the world changes (e.g., new weapons and vehicles, new operational concepts, new doctrine) and goals for the system evolve (e.g., shift from focusing on conventional conflict to focusing on missions other than war). To remain effective in the long run, a system must be maintainable and extensible; to remain cost-effective, as much maintenance and authoring as possible should be supportable by available staff and those with first-hand expertise in the domain.

Raw manipulation of the underlying data structures that enable an ITS to function tend to require detailed expertise in artificial intelligence (AI) and ITS technologies. To enable domain experts to take on maintenance and authoring tasks, manipulations of system structures must be translated into terms that are meaningful in the domain. Furthermore operations must be clustered, sequenced, and modeled so that appropriate system modifications become easy, and invalid modifications become essentially impossible. Achieving these ends requires creation of application-specific authoring tools. Since we see this as an important consideration in every ITS we construct, this is an area where SHAI has had extensive experience.

Phase I Objectives and Accomplishments

Phase I Objectives

During Phase I, our objectives were to:

1. Identify the kinds of **tactical analysis knowledge** that should be represented by the system to support the evaluation of learner solutions to tactical scenarios, in order to refine the system's student model.

2. Explore and evaluate candidate **interaction techniques** that can achieve the types of instructional goals currently achieved in learner/mentor interactions with expert human instructors.

3. Identify the types of **automated tutoring strategies** needed to select and generate effective instructional interventions based on a student model.

4. Develop methods for **authoring ITS scenarios** by entering good and bad sets of decisions and rationale, and then annotating these solutions with skills that are demonstrated (positively or negatively) by each solution.

5. Develop a limited, proof-of-concept **software prototype** that illustrates key ideas related to learner/mentor interaction methods, tactical analysis knowledge representation, and interactive tutoring strategies.

Phase I Activities and Accomplishments

Our core activities during the Phase I effort included:

a. Study of prior work related to the project goals (e.g., reasoning skills training, ITS techniques and Socratic Tutoring, and the existing Think Like a Commander course).

b. Conduct, observation, and analysis of a series of Tactical Decision Game tutoring sessions between active-duty Marine Captains and acknowledged tactical (and tutoring) experts.

c. Design and construction of a proof-of-concept ComMentor prototype based on a single TDG scenario covered in multiple tutoring sessions.

With respect to our original objectives, activities ‘a’ and ‘b’ directly addressed objectives 1, 2, and 3. Our early work on activity ‘a’ helped frame the problem. The extensive observations and analysis in activity ‘b’ ended up forming the primary basis for most of our work; identification of knowledge form and content, interaction techniques, and tutoring strategies all fed forward into later objectives. Activity ‘c’ directly addressed objectives 4 and 5. Our work on objective 4 was not only a necessary precondition to success on objective 5, but forms the groundwork for Phase II work on task-specific authoring tools. Likewise the prototype produced for objective 5 not only demonstrates the feasibility of our ideas, but also serves as a design base and source of lessons learned for our proposed further system development during Phase II.

ARI Direction and Materials

Discussions during the project kickoff meeting held at U.S. Army Research Institute for the Behavioral and Social Sciences (ARI’s) Fort Knox office, in combination with review of the Lussier, Ross, & Mayes (2000) provided our initial direction on the project.

Much discussion focused on ARI’s efforts to develop the Think Like a Commander TLAC course, as an example of what training in battlefield command reasoning skills might look like. We were given access to initial materials on TLAC, including preliminary instructors’ notes being compiled by Col. Fontenot under contract to ARI at Fort Leavenworth. It was suggested that we might want to base our analysis and development efforts on the TLAC materials, and that we might want to follow a new direction ARI was establishing to retarget TLAC materials towards training Captains (rather than Colonels).

Following up on this initial meeting, we were provided with some of TLAC scenario and vignette briefing materials, as well as videotapes of TLAC class sessions run at Fort Leavenworth. Ultimately, we were invited to join a group of other contractors in visiting Fort Leavenworth to observe TLAC courses for a day. We observed two classes, each about 50 minutes long. Interestingly (disappointingly), from the perspective of our goal to develop a tutoring system, the TLAC class sessions involved between 10 and 20 students at a time, and spent only about 15-20 minutes on each vignette. As a follow-up to this trip, we received a more extensive packet of material intended to provide TLAC students with a detailed background scenario supporting interpretation of the several TLAC vignettes.

Finding the available TLAC observations (video and live) limited in their usefulness for our tutoring analysis purposes, we had been planning to stage our own simulated TLAC sessions using our domain expert consultants as instructors. Our experts, however, were more comfortable working with their own TDG materials, since they found the overarching TLAC scenario (with its staggering wealth of documentation) difficult to master and not significantly more conducive to enabling effective training in battlefield command reasoning skills. We had also been studying TDG material (e.g., Schmitt, 1994) as part of our project effort. Fortunately, ARI had made it clear that TLAC was being offered as an example and a resource, rather than a dictate, so we were free to take what we had learned from our studies of TLAC and transfer it to the TDG framework.

TDG Observations and Analysis

Our experience with TDGs began with a sample session during which staff from SHAI and our psychology subcontractor played "student" to one of our subject matter experts as "instructor"; we played the "Tanks on the Farm" (ToF) scenario. This was a valuable experience for several reasons. First, it introduced us to the on-line distributed format and infrastructure that our subject matter experts had developed for electronic TDG training; we found this to be a convenient, cost-effective, and pedagogically effective approach. Second, it introduced us to the particular TDG scenario that would ultimately become the focus for the bulk of our Phase I analysis and implementation. Third, it demonstrated convincingly that we needed real military personnel to play the role of student if we wanted to observe more interesting tutoring behavior.

Based on their expertise and reputation as outstanding tactical instructors, our subject matter experts were able to recruit active-duty Marine Captains (themselves all tactical instructors) to serve as students in our tutoring observations. In all, we held six observed tutoring sessions, each about an hour and a half in length. Our two experts took turns as lead instructor: generally the lead instructor would handle the first 45 minutes or so of the session, then the alternate instructor would weigh in for about 30 minutes covering topics they thought had been missed, and finally the lead instructor would close out the session. In all cases, one of our subject matter experts was physically on site with the student, while all other participants were spread across the country, observing manipulations of a scenario map on a shared whiteboard, and listening to audio over a teleconference line. Four different students were involved. Three different scenarios were covered in these sessions, offering a range of complexity. We devoted three sessions to the ToF scenario, two sessions to a somewhat more complex "Defense of Glosson" scenario, and one session to the very complicated "Evacuation from Enniottu City" scenario.

For all six of the formal observational sessions we had two observers from our psychology subcontractor, and at least one from SHAI. Staff from ARI at Fort Knox joined us in observing the final session. Video and audio recordings were made of the computer screen and phone conversations in all cases. Rough on-the-fly transcripts were created in real time. Ultimately, we focused our analysis on the three ToF sessions, compiling detailed annotated transcripts of the proceedings. Samples of these are included as Appendix B at the end of this report.

ComMentor Design and Implementation

As the tutoring sessions progressed, we began to refine our ideas on the design of the Phase I ComMentor prototype. We identified a finer set of distinctions in the knowledge required to support robust tutoring. We identified a modular breakdown appropriate to these interacting forms of knowledge. We began the process of implementing the identified knowledge bases and processing modules.

Phase I Findings

The findings from our Phase I effort can be categorized under three divisions, mirroring the activities just described: (a) Study of ARI directions and Materials; (b) TDG observations and analysis; and (c) ComMentor design and implementation.

Findings Based on ARI Direction and Materials

We took away a small, but important set of lessons from our early survey of the problem and prior work:

1. There are vanishingly few opportunities for officers—especially junior grade officers such as Captains—to get one-on-one instruction in battlefield command reasoning skills. TLAC is a very innovative course, but it is available on only a quite limited basis. At the time we were doing our study, it was only available to quite senior officers, only in large group settings, and only for small amounts of time.

2. It is unclear that the depth of background provided by the overarching TLAC scenario that frames the smaller TLAC vignettes is strictly necessary if the goal is to provide sufficient fodder for interesting battlefield reasoning exercises. The TDGs are exceptionally concise in presentation, and needed contextual information is either plausibly assumed, or introduced by the instructors on an as-needed basis.

3. Prior work in the context of TLAC had identified an interesting set of analytic levels (or scaffolding levels) at which battlefield command reasoning skills could be drilled: (1) **Situation Analysis**—i.e., "What do you know?" "What do you think you know?" and "What do you need to know?" (2) **Situation Response**—i.e., Role-playing the issuing of orders, reports, and requests with feedback of relatively immediate replies and consequences; and (3) **Context Analysis**—i.e., analyzing the longer-term and second-order effects of decisions made to cope with an immediate situation, including formation of future policies to avoid recurrence of problematic situations, or to ensure adequate flexibility to deal with them when they arise. Our own observations suggested adding two more levels of interaction: at the low end (0) **Fact Filling**—i.e., having the instructor fill in missing factual information (e.g., on weapons capabilities) and on the high end (4) **Behavior Modeling**—that is, having the instructor model effective reasoning and behavior after the students have made their attempts.

4. When attempting to model and simulate the actions of expert tutors in mentoring students at a particular level of expertise, there is no substitute for observing real tutoring sessions between real experts and real students. Short group sessions will not provide the material for modeling extended one-on-one interactions. Simulations with fake students will not elicit the same kinds of tutoring behavior as will interactions with appropriate students.

Findings Based on TDG Observations and Analysis

The TDG tutoring session observations were central to the entire direction and outcome of our Phase I effort. Beyond the project's basic purpose, and the projected system's form, and

core underlying technologies, essentially everything about the Phase I prototype was determined based on observations of these sessions. Here, as a main result, we focus on our preliminary taxonomy of tutoring moves as shown in Table 1.

Table 1 is broken into four main blocks:

1. Basic Scenario-Based Socratic Tutoring: This block organizes the core set of moves the instructor typically makes when guiding a student through thinking about a particular scenario.

We start by dividing essential factual information into that which is peculiar to the scenario at hand, and that which is general to the domain. Key instructor moves related to such facts include four *active* moves: (a) **presenting** the relevant facts to the student (e.g., introducing and setting up the scenario), (b) **correcting** student misstatement of facts (either directly or by querying them), (c) **clarifying** slightly misstated or incomplete facts (again either by statement or query), and (d) **recapping** a set of facts. This last variation on fact presentation is especially interesting, because it can embed a focusing and framing intent—that is by choosing which facts to include or drop from the recap, the instructor gets to focus the student on essential constellations of facts. It is characteristic of Socratic tutors to often adopt a more *passive* role with respect to fact statement—that is to ask questions instead of make assertions. We thus consider the following pair of moves critical in our analysis: (e) **probing** for the student to state a fact, and (f) **refining** the probe to get the student to clarify an incorrectly or incompletely stated fact.

Table 1.

Phase I Analysis – Representative Taxonomy of Tutoring Moves

1. Basic Scenario-Based Socratic Tutoring
- Present/correct/clarify/recap scenario facts
- Present/correct/clarify/recap domain facts (respond to student questions)
- Probe/refine for domain fact understanding
- Probe/refine for scenario fact understanding
- Probe/refine/lead/clarify/recap for scenario situation assessment
    - What is key missing information?
    - What are possible alternatives?
- Probe/refine/lead/clarify/recap for decision details
- Probe/refine/lead/clarify/recap for decision rationale
- Direct student action

2. Topic Management
- Instructor-driven
    - Explicit vs. implicit
    - Shifting vs. digressing vs. abandoning
- Student-driven
    - Accepting vs. deferring vs. rejecting

3. Theme-Specific Tutoring (examples)
- Focus on Mission & Higher's Intent
    - Does higher know what you know? What should they know?
    - Has your mission changed? If so, why and how?
- Thinking Enemy
    - What are they doing there? What is their goal?
    - What might their plans be?
- Big Picture
    - What don't you know in your situational awareness (SA)?
- Visualization
    - What will happen after this engagement?
    - How will you shape the future battlespace?
- Contingencies and Flexibility
    - Hypothetical variants on base scenario

4. Alternate Sub-Session Formats
- Role-play
    - Play at self vs. commander vs. enemy, etc. (varying levels of competence/personality)
- Behavioral modeling
- Theoretical discussion
- Anecdotes
- Motivation
- Reflection
    - Ask student to assess own performance (best, worst)
    - Ask student to recap key learning points (what would do different?)

Moving beyond the facts, a tutor/student interaction starts to focus on situation assessments (inferences), decisions (intentions), and decision rationales (reasoning processes, and decision justifications). Some, but not all, of the moves just identified for facts apply to these higher-order constructs. In particular, tutors, for the most part, do not present or correct assessments, decisions, and rationales. They are frequently observed **probing** for student statements of these constructs and **refining** their probes to get at details (e.g., "*Why did you do that?*" or "*What were you thinking?*" vs. "*Why are you worried about that [protecting your left flank]?*"). The goal is to get the student to think, and articulate their thinking. One novel move that appears in this context is the (g) **leading** question[1]—a tutoring move that stops short of being a presentation or correction (at least syntactically), but more or less strongly influences the student to focus on particular issues or facts, or to see things a particular way. Once the student makes some higher-level statements, tutors may feel free to make **clarifying** or **recapping** statements as they would with facts. Again, recapping—as a kind of editing—can have a powerful influence on the future direction of the session.

We have included two sample generic questions in this first block illustrating approaches to *scenario situation assessment.* One interesting point is that these questions are very generic—not tied at all to any particular scenario, or any particular aspect of a scenario. Another point is that these questions could equally well appear elsewhere in the table—in particular as examples of pursuing particular battlefield reasoning themes sampled in the third block of Table 1. Essentially the same instructor behavior can be motivated in different ways, and be intended to serve different ends, depending on circumstances.

The final kind of tutoring move we include in this section is the explicit directive to manage student action. Typical examples would be "*Issue your orders*" or "*Draw me a picture of that.*"

2. Topic Management: The second block of Table 1 simply acknowledges that an extended conversation, such as a Socratic tutoring dialog, has an internal topic structure, and there are often (overt or covert) moves to control the topic. We start by noting that a dialog, inherently offers the possibility for mixed control over issues such as topic; however, we continue to look at things from the instructor's perspective.

Accordingly, we suggest that the instructor can make the following moves based on their own assessment of conversational flow: (a) **shifting** the topic in an orderly planned way (either explicitly, e.g., "*OK. Let's take a different approach. Let's take a look at your tactical plan.*" or implicitly, e.g., "*What do you think about the way you've got your forces arrayed to take care of his push from the East?*"), (b) **digressing** to temporarily address a sub or side-topic while

[1] We note that leading questions may be used for purposes other than getting the student to see a point the instructor wants them to see (or at least can end up having other effects). They can also be used for diagnosis, or for setting traps for the student to fall into—that is, for verifying tutor hypotheses that it is worth spending time drilling in a particular area. For example: "*So you think the idea of the Assembly Area in Viettiville is still viable at this point?*"

planning to resume the current topic later, and (c) **abandoning** a line of discussion to deal with some other, presumably more important topic opportunity that arose in mid-discussion.[2] We also suggest that an instructor can respond to student attempts to change the topic by either (d) **accepting** the new topic, (e) **deferring** the new topic for later discussion, or (f) **rejecting** the new topic outright. We actually have very few examples of students trying seriously to redirect their tutoring sessions—a likely mark of their acceptance of the instructors' expertise and authority, and of their willingness to be guided. It is an open question as to whether that bias will carry over to the automated tutoring context.

3. Theme-Specific Tutoring: The third block of Table 1 shows how a set of relatively generic (for the domain) questions can be identified for some of the specific themes central to battlefield command reasoning (e.g., a sampling of the eight themes identified as underlying TLAC). In any given circumstance, most of the questions identified here could be classified as to their purpose according to the scheme laid out in Block 1 above (Basic Scenario-Based Socratic Tutoring). It is, of course, possible to get arbitrarily more scenario-specific in such questions. The point, however, is that it is often possible to identify specific tutor moves with specific curricular goals (in this case, eliciting and reinforcing certain critical identified aspects of battlefield reasoning thinking skills), rather than with abstract tutoring strategies.

4. Alternate Sub-Session Formats: The final block of Table 1 highlights that even in the context of a primarily Socratic tutoring session, there is room to use a wide variety of pedagogical techniques. We observed our instructors using all the approaches listed there. Most obviously, **role-play** was a significant and adaptable tool in their kit. Students were variously asked to play themselves (that is, commander of the tank battalion at the center of the ToF scenario), their superior commander, or various enemy commanders. An interesting technique used to get students to consider alternatives and contingencies, and to model a thinking enemy, was the suggestion of specific ranges of competence or personalities for enemy commanders. Often the play was aimed at specific issues or answering particular questions. Sometimes, the play was extended to consider possible temporal sequences, and thus grew into small-scale low-fidelity micro simulations. In such cases, preliminary inspection suggests it is plausible to base such plays on local scenario-specific scripts.

As noted in "Findings Based on ARI Direction and Materials," we observed our instructors sometimes engaging in **behavior modeling**—that is showing the student how the expert would do something—generally after giving the student a chance, or several chances, to do the job themselves. Likewise, we saw them devote limited time to **theoretical discussions** of such important concepts as *shaping the battle*. On occasion, they used personal **anecdotes** to make points (e.g., *I've been in tanks under heavy artillery fire, and it's amazing how tough even a little bit of armor is.*).

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[2] It may be questionable how frequently it is useful or possible to distinguish between digressing and abandoning—that is how often an instructor really plans to abort a line of discussion, versus how often they simply get distracted and don't happen to remember to come back to the topic. Discussion with one of our subject matter experts suggests that often what appears as the instructor abandoning a topic is really a response to subtle cues (e.g., body language) indicating that the student is not benefiting from the current line of attack. That could be either because the student already gets the point (so the current tutoring goal is accomplished, and it is time to shift focus), or because the student is not following the line of discussion (and so it is time to shift strategies, while still addressing the same tutoring goal).

One point, that has only been suggested so far, is that there is a definite large-scale structure to an entire tutoring session. Clearly, it starts with a presentation of the scenario. The session generally proceeds through an elicitation of the student's initial response to the initial scenario challenge. There is a range of possible responses that trigger focus on a range of possible discussion topics. For any given scenario, some topics tend to come up earlier in the discussion, and some topics tend to show up late, if at all. Eventually the session ends, and in all cases we observed, the instructors closed by encouraging a period of **reflection**. That is, just as they had a reasonably tight script to launch the session, they had a script to end it as well, by asking questions such as "*How do you think you did?*" "*What do you think you did best?*" "*What do you think you did worst?*" "*What did you learn?*" "*What would you do different next time?*"

The above is clearly a preliminary analysis, but reflects the breadth of our Phase I observations. The value of this kind of taxonomy, and of accompanying observations, such as on the gross structure of tutoring sessions, is to begin to provide a way to think about structuring an automated tutor's behavior.

Findings From ComMentor Design and Implementation

As we moved from observation and analysis into design, we identified several other aspects of the tutoring sessions that drove us to evolve beyond the implementation ideas presented in our Phase I proposal:

- We observed that combining text and graphics was very important to duplicating the kinds of interactions we were observing: sometimes a map manipulation can clarify an otherwise ambiguous utterance, and sometimes a description of rationale can clarify an otherwise mysterious set of moves on the map. Accordingly, we are devoting substantial resources to supporting multi-modal interaction in the Phase I ComMentor prototype.
- We observed the use of simple "role-play" snippets (e.g., issuing of orders, consideration of hypothetical follow-on scenarios) and felt that separating the tutoring interface from a "role-play" interface would help to clarify (both for the student and the system) what kind of interaction was going on at any given moment.
- We observed the importance of having a basic competence to reason about simple quantity, time, distance, and force issues (what was often referred to as "battlefield calculus"); it appears that while Captains can benefit tremendously from tutoring in battlefield reasoning skills, they often need support in managing the basic facts of the situation.

These and other points are illustrated by the Phase I software prototype.

Phase I Prototype System

As part of this Phase I effort, we built a limited proof-of-concept prototype Socratic ITS for battlefield command reasoning skills. We call this prototype "ComMentor"—the Command Mentoring system. This section provides a detailed discussion of the goals, structure, internals, and behavior of the ComMentor system.

Prototype Goals

Our goals for the Phase I prototype ComMentor system included the following:

1. Demonstrate the possibility of automated Socratic tutoring in a battlefield reasoning application;

2. Demonstrate the applicability of the Socratic tutoring principles identified above;

3. Explore architectural options for an automated Socratic tutoring system implementation;

4. Help develop requirements and designs for a more complete Phase II prototype.

General Discussion of Prototype Scenario

Our Phase I prototype presents a clear image of the kind of system we propose to construct during this Phase II effort. A lesson is centered on a Tactical Decision Game (TDG) scenario presented by a combination of a situation map, a set of force structures, and a textual description. The description will generally contain discussion of the Blue unit that the learner commands, the learner's orders, intelligence about the enemy, and often some critical incident that starts the action in motion (a "trigger event" that triggers the need for a decision). For example, as described earlier, in Phase I we developed a scenario around ToF TDG. Figure 3 is a version of the scenario's introductory text. Figure 4 shows the ComMentor screen layout with the ToF situation map and force structures displayed.

At this point, the student can be prompted for a decision. Based on extensive experience playing this game with a wide range of students, our domain experts indicate that, at a high level, students essentially always take one of three approaches:

1. The student decides to try evading the enemy force so as to continue on to the assigned position at Viettiville.

2. The student decides to react to the presence of the enemy force in a cautious way that involves significant preparation and maneuvering.

3. The student decides to take on the enemy force with a rapid race to the top of Balzer hill that preserves the element of surprise for Blue.

Any of these responses provides an opening for interesting discussion and analysis. Typical issues that can be well addressed in the context of this scenario include:

- Interpretation of commander's intent.
- Modeling a thinking enemy.
- Assessment of the big picture.
- Visualization of an evolving battlefield.

- Recognizing contingencies and maintaining flexibility.
- Reasoning about time.
- Exploitation of terrain.
- Basic "battlefield calculus" (time, distance, and force calculations).

You command a tank battalion of four companies of M1A1s, with a section of eight tube-launched optically-tracked wire-guided (TOWs) mounted on high mobility multipurpose wheeled vehicle (HMMWVs). Your division has been fighting elements of the enemy 6th Division, a battle-hardened outfit of three maneuver brigades supported by an armored reconnaissance battalion and an artillery regiment. Typically, a reconnaissance company and artillery battalion will support each maneuver brigade. Intelligence estimates that 10 Brigade, the toughest formation, is at about 80% strength and that 20 Brigade is at about 50-75%. After having been pulled out of action some two weeks ago for refitting, your battalion is now once more near full strength. You are making a night administrative move on improved roads to your new assembly area in Viettiville, where you will be part of the division reserve. The front is about 10-12 km east of the east edge of the map. During the move you are instructed to observe radio listening silence.

The enemy has been attacking from the east with armor and mechanized infantry, usually leading with a battalion of tanks preceded by a reconnaissance company on one or more axes depending on the terrain. Cross-country mobility for armor is good, except in wooded areas, which are essentially impassable to vehicles. The division commander feels the time is about right for a counterstrike. Division intends to use your battalion to spearhead a counterattack out of Viettiville, direction and objective to be determined as the situation develops, in order to destroy the enemy's armor, seize the initiative and transition to the offensive. You are expected to be in Viettiville by 0630, about 90 minutes from now.

At the head of the battalion march column, you approach Balzerton from the southwest as the day begins to dawn. It has been an uneventful road march. During the night you heard some traffic on the division command net about skirmishes with enemy infantry, but no major activity. But then you are contacted on the radio by a section of light armored vehicle (LAV)-25s performing rear-area security. They had passed you earlier on the road and are now in Balzerton. The light armor section leader makes the following report:

I count about 25-30 T-72s—I say again, T-72s—at Vietti's Farm. They are apparently laagering; I see dismounted crews. I see a pair of T-72s, apparently scouts, approaching Balzer Hill from the east; they'll be in position to see you in less than five mikes. I spot a convoy of trucks—about a half dozen, including refuelers—approaching the farm on the Viettiville road, about three clicks from the farm. I am unobserved.

The section leader's voice is urgent, but not panicked. He is sure of what he sees.

Figure 3. Tanks on the Farm Introduction.

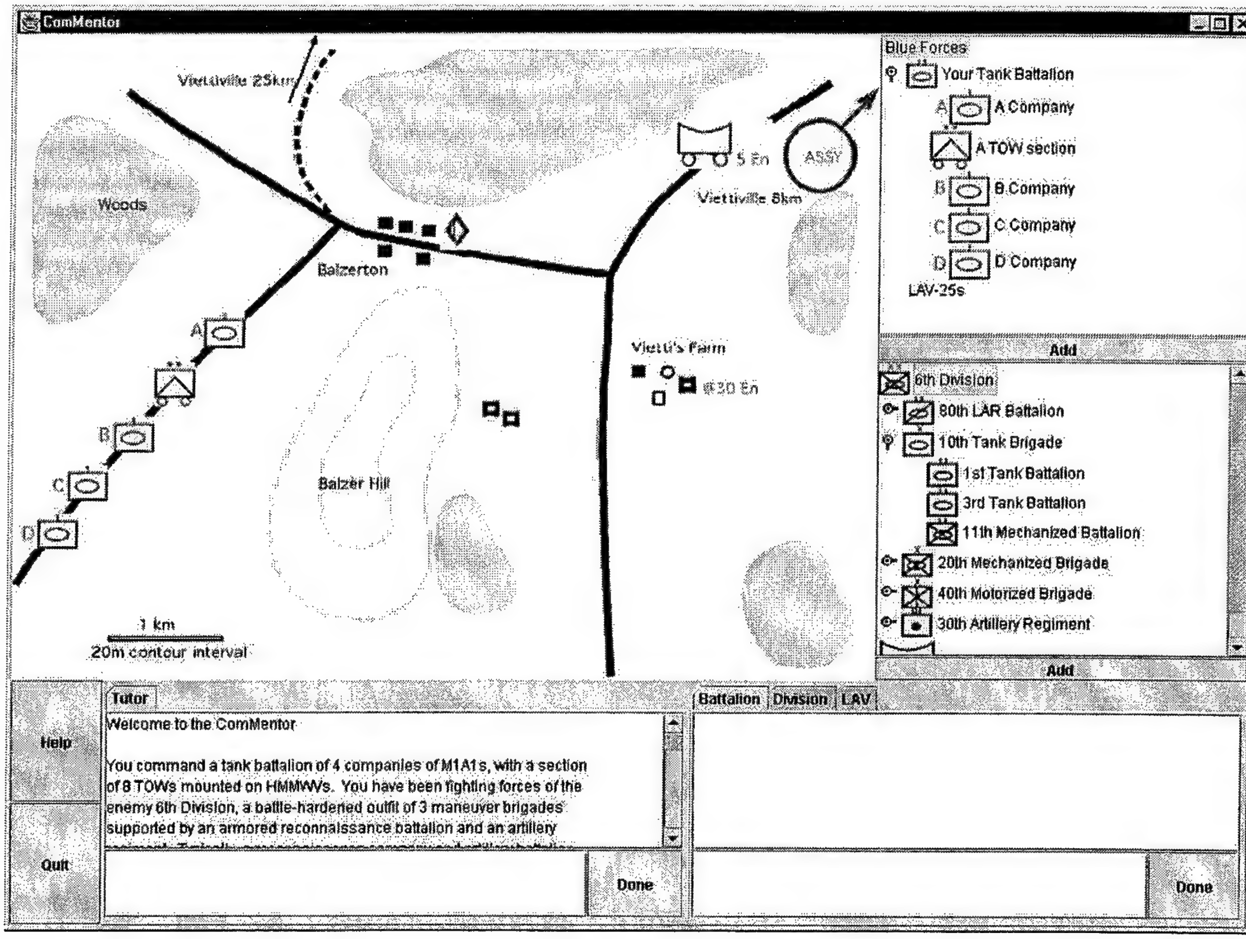

Figure 4. ComMentor Screen Layout w. ToF Map and Force Structures.

Of course some responses make it easier or more natural to talk about some of these topics than others. For instance, if the student chooses the first option—avoiding the pending confrontation in favor of following the original orders—it is natural to begin a discussion about the big picture and acting in concert with the commander's intent. An important aspect of understanding this scenario is to see that the laagering tanks are likely to be the lead battalion of an enemy breakthrough from the East. Given the lack of radio traffic reporting such a major incursion into Blue territory, Division command is likely not yet aware of what is going on. Furthermore, enemy logistics trucks coming down the road from Viettiville suggest the intended assembly area is already compromised. In light of all this, assembling at Viettiville in order to launch a counterstrike and destroy enemy armor is now beside the point. The student has an opportunity to seize the initiative and start destroying enemy armor right here and now.

If the student seems to have chosen the second or third option, the interaction goes somewhat differently. It is still worth exploring the issues of situation assessment and commander's intent, but the conversation now is oriented towards probing the student's rationale in order to confirm that they took their actions for the right reason. If such probing confirms an appropriate rationale, then the discussion can move on to other topics. For instance, if the student has taken a slow cautious approach, the discussion can turn to appropriate use of time

and exploiting the element of surprise; among other possible directions, this may lead to reviewing issues of "battlefield calculus" (e.g., time, distance, and force calculations). If the student has moved quickly and decisively to destroy the laagering tanks, then after another rationale confirmation discussion, the tutor might focus on the specifics of their plan: e.g., the deployment of available forces, effective use of terrain, awareness of possible ambushes, and even the form in which orders were issued.

Given enough guidance, pretty much any student can be led to an understanding of the big picture, and to an appreciation of the value and appropriateness of decisive action. But there is potentially still more to this scenario. An assessment of the big picture raises questions about the larger enemy element the laagering T-72s belong to, and that larger enemy's likely intentions. It raises questions about the fight after the current fight, and the relation of the current situation, not only to the commander's original intent, but also to the commander's situation awareness and likely future intent. This relatively simple scenario, thus serves as a context in which to address a large number of battlefield reasoning themes.

Points Illustrated by Phase I Prototype

The Phase I prototype as demonstrated at ARI on 7 June 2001 illustrates many of the points central to our approach to building Socratic ITSs for high-level reasoning skills. In this section we will review those points and the prototype capabilities that relate to them.

Our observations of tutoring sessions convinced us of the importance of supporting multi-modal input and output. In those sessions, the primary modes were graphics (task organizations and manipulable maps) and speech. In our implementation we aimed to duplicate the graphics capabilities and substitute natural language text for the observed speech[3]. The scenario introductory sequence illustrates the ability of the system to output both text and graphics. The text is currently output as one large block into the "Tutor" pane (refer again to Figure 4). The system is capable of directing individual blocks of text to any of its text output panes (e.g., the role-play channels for "Battalion," "Division," or the "LAVs"). On the graphic side, the task organizations for both Red and Blue are displayed as (expandable/contractable) hierarchical trees with appropriate icons (the upper right-hand column in Figure 4). The underlying situation map is a prepared image file, but the placement of moveable items such as the Red and Blue units are under program control (in the upper left-hand block of Figure 4).

Multi-modal input (graphics & text)

The prototype illustrates an example of the multi-modal input capabilities we identified as important to a naturalistic tutor. On the text side, we showed that the system can parse orders to units and instantiate underlying assignment structures. On the graphics side, we showed that the student could manipulate the icons on the map, dragging them to new locations as desired to help illustrate a plan. The system is able to compute a range of simple spatial predicates to describe icon placement, and uses those to attempt to verify that the icon locations match up with

[3] As noted during our presentation, it would not have been tremendously hard to demonstrate speech *output* in our prototype, but resource limitations argued against it. The proposal for Phase II addresses the issue of speech *input*.

the orders previously given in English. Thus the system can use information acquired from these two input modalities together, to build a more robust understanding of the student's intentions.

Free-form input (natural language)

When it came to inputting orders, we demonstrated the ability to parse rather varied and complicated expressions for the assignments that represent the student's plan for his units. Our domain experts consider language a far superior form for initial input as compared, say to menu systems or map overlay manipulation, because it corresponds closely to the real task, and neither leads the student to a likely answer, nor promotes inappropriate abstraction of moving game tokens on a board. In our demonstration sequence we input a set of orders roughly as follows:

> *Alpha go to Balzerton and observe laagering tanks. Bravo stay west of Balzer Hill and wait in reserve. Our tows should also stay west of Balzer and wait. Charlie move onto Balzer Hill and fire on enemy scouts when in range. Delta move south of the hill and observe laager formation.*

While our parser is not yet a robust capability, it illustrates the promise of taking a situated semantics-first approach to input text interpretation. Similarly we were able to parse a range of factual and hypothetical statements about the situation, as well as various fragmentary and elliptical utterances contextualized as answers to tutor questions. Many issues remain however, including more effective handling of conjunctions/compounds, as well as pronoun references and elisions. Some other specific features identified for inclusion in Phase II include: (1) feedback to the student to clarify the system's interpretation of their input; (2) on-demand hints to the student on the types of input that are currently expected; and (3) spelling correction on inputs to minimize misunderstandings based on flawed inputs.

Multi-part input (multiple sentences)

One important aspect of the prototype's free text input capability is that it is able to deal with fairly arbitrary blocks of input text. In particular it is not limited to one well-formed sentence at a time. When accepting the student's orders to his battalion, the prototype can parse any number of sentences together, including sentences with more than one phrase (e.g., both a maneuver and a military objective). This is important since our observations of students indicate that they will generate utterances of vastly differing lengths and completeness. Going forward we have planned extension mechanisms to deal with even more radically abbreviated and extended forms of input.

Student solution gap-filling

Student input can come in different sized chunks, and that implies different degrees of completeness after one or several inputs. For instance, when the system has asked the student to enter a set of orders, it has an idea of what would constitute a reasonably complete input. So long as it is missing items it expects, it will prompt the user to fill in missing pieces at the end of each received piece of input. In the demonstrated prototype, this is illustrated by prompts for orders to units that have not yet been given any instructions. It is also possible to prompt for

missing details in orders to a particular unit—for instance if a unit is told to move somewhere, but is not told what to do when it gets there.

Student solution classification

Once a set of orders are input as text and verified through graphical manipulations the system attempts to classify the student's proposed response to the scenario situation. For example the orders shown above from our demonstration sequence can reasonably be classified as a cautious approach to the situation. The student is not running away from the enemy, but neither is he seizing the initiative and attacking the main formation. The tutoring that ensues addresses the issues of time and distance and initiative. In particular, what is going to happen when the enemy scouts get to the top of the hill and discover elements of the student's battalion? Contrast this with the following alternate, more aggressive, orders that the student may enter on a later cycle through the *solicit-orders→classify→tutor* cycle:

> *Alpha go to Balzerton and observe. I also want my tows to move to Balzerton. Bravo you move to the top of Balzer Hill and open fire on enemy tank battalion. Charlie go to top of hill also and attack the enemy tanks. Delta head to south of Balzer Hill and observe.*

Here the student is planning to directly take on the main enemy formation. The system diagnoses this as fitting its bold case. In this case the system drills on how the user's immediate and future actions relate to the higher commander's intent.

Case topic/theme scripting

As noted, the two cases just illustrated lead to tutoring on somewhat different topics or themes. The important point is that each diagnostic case fragment suggests a set of topics worth covering. The cautious case leads to a line of discussion about the situation and the enemy's intent that includes questions such as:

> *What do you think is at Vietti's Farm?*
> *What are they doing right now?*
> *What do you think they'll do when they're finished refueling?*
> *Where is the front line?*

This line of questioning culminates in a recap of the essential facts: "*So we've got an enemy tank battalion refueling deep behind our front line and you think they might be going on the offensive*." It further leads to discussion of time and distance issues with questions such as:

> *How long before the 2 T-72s see you?*
> *How far can your M1A1 travel in 5 minutes?*
> *Who do you think will reach the top of the hill first?*
> *Where will your battalion be when the T-72s hit the top of the hill?*
>
> *What do you think is going to happen [back at the main laager site] when their T-72s up there start shooting and your battalion starts returning fire to the top of the hill?*

Again the line of question culminates in a recap: "*So at this point it seems as though you have lost the initiative as far as engaging that enemy battalion.*" It opens the way to revisiting the initial orders generated by the student:

> *What could you have done differently?*
> *Would you say time is most critical factor here?*
> *Do you want to try again?*

General scenario tutoring cycle

The prototype illustrates a general goal structure for tutoring a scenario. The system sets up the graphical presentation of the scenario and prints the initial situation description. It solicits the student's solution (a set of orders), and verifies those orders by soliciting updates to the situation map. It classifies the student's solution to the current problem and tutors on a set of themes that follow from that case/diagnosis. It potentially offers the opportunity to cycle back and revise the orders, leading to a new solution classification and further tutoring on newly relevant themes. It may move on through a series of decision points in the scenario, each with their own cycle of alternate student solutions. Finally the scenario session ends with an explicit opportunity for reflection. Figure 5 illustrates the general tutorial session goal structure; the italicized lines represent processes that are explicitly part of the model, but were not implemented in the Phase I prototype.

- Run scenario session
  - Set-up map
  - Introduce scenario
  - *Check scenario clarity*
  - Prompt for decision
    - Solicit initial orders
    - Solicit map updates
    - Classify solution case
      - *Check/solicit rationale*
    - Tutor on verified case
    - Possible loop back to prompt for new decision
  - <Additional choice-points and student solution cycles
    - …>
  - Wrap-up session (reflection)

Figure 5. ComMentor General Goal Structure for Scenario Tutoring Session.

Tutor goal management

In addition to a general goal structure for scenario-based tutoring sessions, the Phase I prototype also illustrates a more general goal management mechanism. The system maintains a goal agenda. The active goal is responsible for generating some output (generally a question) to prompt the user for additional input. That goal will also have a set of expectations to be used in interpreting whatever input is received. Depending on the input received and any other facts that have accumulated in the systems session memory, the goal may lead to the spawning of new goals, or may rearrange the contents of the goal agenda. All pending goals can have pending expectations, which can be used to analyze the input should the current active goal not be able to arrive at a suitable interpretation. All together this flexible set of mechanisms allows for (1) sequenced behaviors, (2) branching behaviors, (3) context-sensitive behaviors, (4) varying levels of alternate or default behaviors.

Prompts for reflection

As suggested in "General scenario tutoring cycle," the last part of any scenario session is a wrap-up interaction aimed at encouraging reflection. A standard set of questions is used here including the following:

What do you think you did well in this situation?
What do you think you could have done better?

Going forward, the main issue here is to have the system actually check student input against its record of student solution diagnoses generated during the session. However, even in the absence of a system-generated reality check, a simple canned question sequence begins to serve the purpose of encouraging student reflection on the lessons of the session.

Phase II System Design

Phase II Technical Objectives

During Phase II, we plan first to extend our work on the Phase I objectives:

1. Continue to identify and encode **tactical analysis knowledge** that should be represented by the system to support the evaluation of learner solutions to tactical scenarios, in order to refine the system's student model. In Phase II, particular emphasis will be placed on (a) getting reasonably complete coverage of attributes and inferences in basic areas such as units, vehicles, and weapons, complemented by authoring tools to ease additions and modifications to the accumulated knowledge-base; (b) characterization and prioritization of the space of possible extension sub-domains of tactical analysis knowledge; and (c) further exploration of ways to unify ComMentor's tactical analysis knowledge with other efforts in the Department of Defense (DoD) community (e.g., adoption of proposed knowledge representation language standards and evolving ontologies such as those sponsored in DARPA research programs like high performance knowledge base (HPKB) or command post of the future [CPOF]).

2. Continue to explore and evaluate candidate **interaction techniques** that achieve the same types of instructional goals achieved by learner-mentor interactions carried out by expert human instructors. In Phase II we will devote particular emphasis to (a) exploring the extensibility of our current textual language processing approach versus other more structured input techniques; (b) exploring the applicability of evolving techniques for speech input and output; (c) pushing on the utility of, and coordination techniques for, multi-modal interactions that combine graphics and text (or speech) input and output.

3. Continue to identify, classify, and implement the types of **tutoring strategies that can be automated** in order to select and generate effective instructional interventions based on the student model. Our Phase I work illustrates application of some of the tutoring strategies already identified (e.g., see Table 1 and accompanying discussion). Many of the identified strategies remain to be implemented or even seriously investigated. Others likely remain to be discovered. Our psychology subcontractor is particularly eager, and well positioned to develop a model of Tutoring Instruction/Mentoring Strategies. Additional data collection and preliminary development of such a theory during our Phase II effort should help to provide a firmer empirical and theoretical foundation for ongoing design and implementation efforts.

4. Refine our methods for **authoring ITS scenarios** by entering good and bad sets of decisions and rationale, and then annotating these solutions with skills and knowledge that are demonstrated (positively or negatively) by each solution. In Phase II, emphasis will be placed on systematizing our approach to these tasks, developing custom authoring tools, and embedded guidance in application of those tools. Efforts to ease acquisition of this scenario-specific information complement the efforts in objective 1 to get a handle on the general (domain-specific) tactical analysis knowledge.

5. Develop a fully functional **software prototype** that not only illustrates the key ideas related to tactical analysis knowledge representation, learner-mentor interaction methods, and interactive tutoring strategies, but also serves as an effective learning aid for Army officers. We expect to observe, analyze and implement on the order of another six scenarios during Phase II. In concert with all the objectives listed above, this is a logical next step in efforts to scale-up the techniques identified and illustrated in Phase I.

In addition to the above-stated extensions of the Phase I objectives, we plan to address the following new Phase II objectives:

6. Demonstrate the effectiveness of the tutoring system prototype developed in Phase II. Evaluation will be an ongoing effort throughout the Phase II, starting with formative evaluations of the Phase I prototype, continuing through early user trials and observations of the evolving Phase II system, and culminating in a controlled study of system effectiveness using tactical reasoning skill evaluation metrics and instruments, most likely adapted from those developed by ARI for use in the TLAC program.

7. Develop guidelines and baseline data on scenario authoring. As a result of developing a half-dozen scenarios, we will acquire a far better grasp of effective techniques, typical pitfalls, and likely costs involved in extending the system. In addition to authoring techniques

concretized in authoring tools, and guidelines explicitly embedded in such tools' interfaces and/or help systems, there is likely to be other "wisdom" gained about how to build effective scenarios, including the costs and typical tradeoffs inherent in such efforts. The results of objectives 6 and 7 together will feed into addressing our final objective number 8.

8. Develop a preliminary analysis of the issues likely to bear on long-term acceptance, effectiveness, and maintainability of an expanded, fully operational ComMentor. In addition, consider the portability of the techniques embedded in ComMentor to other, more commercial domains and applications.

Phase II Architecture

Figure 6 shows the architecture of the proposed ComMentor system, broken down at the top level into (1) the ITS User Interface, (2) the ITS Core Processes, (3) the ITS Authoring Tools, and (4) a set of persistent knowledge bases. The main knowledge bases reflect and support much of the underlying structure of the system. For instance four distinct components of the Authoring Tool suite address each of the four major types of knowledge: Domain Knowledge, Scenario Knowledge, Curricular Knowledge, and Instructional Control Knowledge (or strategies). Likewise, those kinds of knowledge (as well as the individualized student model) enter into the main ITS operations primarily through distinct processing modules.

One major effect of this design is to simplify knowledge acquisition, as subject matter experts will ultimately spend most of their time entering tactical analyses for each scenario, and will not need to concern themselves as frequently or deeply with other more stable sorts of knowledge (for instance, determining *how* the newly entered scenario knowledge will be used). A related effect, then, is to allow for more flexible use of the tactical analyses, as the Case Assessment Module can employ a wide range of algorithms for comparing the student's solution with those of the experts to find significant similarities and differences, and the Tutor Interaction Module can likewise use a wide range of algorithms to select instructional interventions accordingly. Finally, this kind of separation allows the system to evolve more gracefully to incorporate new and improved technologies, by supporting piece-wise replacement of the software modules. For example, in Phase II we intend to explore modification of the User Interface by introduction of a Speech Output Generator and Speech Input Analyzer, and expect minimal impact on the other major modules and knowledge bases.

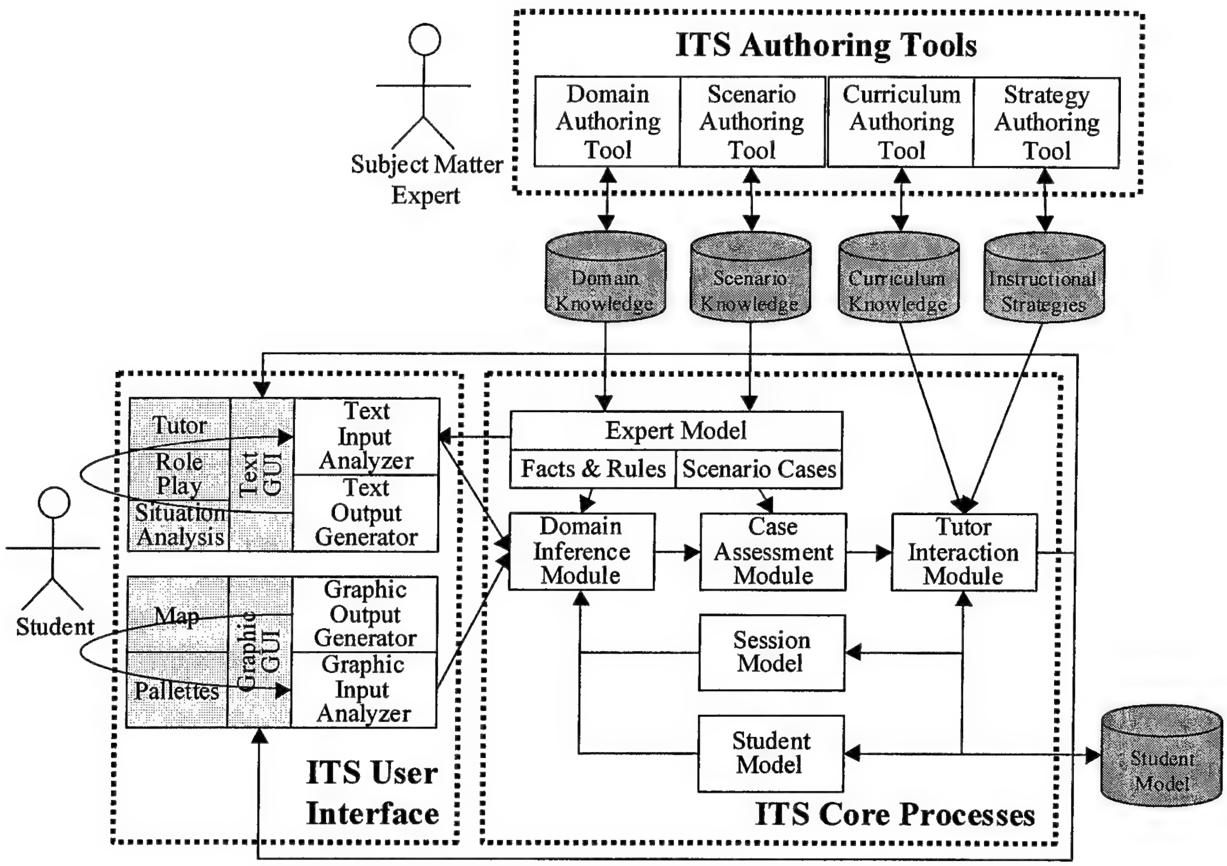

Figure 6. ComMentor Phase II System Architecture.

Phase II Components

The ITS User Interface

The ComMentor User Interface supports all interactions with the user. Specifically, as illustrated in Figure 4 and Figure 6, this module:

- Presents tactical scenarios to the learner in the form of a map display plus narrative.
- Accepts solutions from the learner in the form of texts (orders, reports, requests, augmented with tutorial questions and answers), supplemented by map manipulations (placement of icons, and annotation with regions and paths).
- Enables an interactive multimodal instructional dialog that combines graphical and textual input and output, while embodying a range of pedagogical strategies.

The above is a fair characterization of the capabilities illustrated by the Phase I prototype. In addition, during Phase II, we intend to experiment with other forms of interaction. As noted earlier, the most likely candidates are:

- Presentation of war stories that illustrate lessons related to the learner's solution and/or reasoning.
- Extension of multimodal capabilities to include speech input and output.

The ITS Core Processes and Knowledge Bases

The core ITS shown in Figure 6 elaborates on the abstract version of the architecture originally shown in Figure 1. The basic pipeline structure—from the input modules, to the Domain Inference Module (DIM), to the Case Assessment Module (CAM), to the Tutor Interaction Module—is preserved. Remember, the idea is that successive modules raise the level of abstraction in the situation description to arrive at a useful tutoring-relevant characterization. For example, the input module might be able to generate the characterization: "*Alpha tank company is north of Balzer Hill; Bravo and Charlie companies are on top of Balzer Hill; Delta company is south of Balzer hill.*" The DIM might elaborate: "*Alpha and Delta companies are not in range to attack or be attacked by the enemy tank formation, and Delta company cannot be seen by that formation; Bravo and Charlie companies can attack the enemy formation.*" The CAM might say: "*The student might be proposing to use some tank companies, located on the key terrain of Balzer Hill, to attack the enemy tank formation; if so, that is a recognized solution, and it suggests some specific tutoring interactions...(e.g., verification of plausible rationale).*" Figure 6 unpacks some additional details, primarily related to the knowledge bases that support the processing modules' activities.

For instance, Figure 6 calls out in detail how the Expert Model is composed of combined information from the Domain Knowledge Base and the Scenario Knowledge Base, and how that combined expert model supports both the Domain Inference Module and the Case Assessment Module. In addition, Figure 6 shows that the Expert Model contributes lexical/conceptual information that configures the Text Input Analyzer to enable parsing of user utterances.

The Domain Knowledge Base contributes baseline facts such as "*an M1A1 has an effective range of 2km*" or "*the top speed of a T-72 over open country is 60 kmh*" and rules such as "*if an enemy target is in range of a weapon, then it can be attacked using that weapon.*" It may also contain tactically relevant knowledge about how such facts can be modified by mitigating factors such as night operations, crew training, weather, etc. In such cases, capturing possible ranges, and the contextual parameters they depend on is a useful technique. Over time the Domain Knowledge Base can potentially be extended to support such forms of reasoning as trafficability analysis, in order to make more nuanced predictions about how long certain battlefield maneuvers might take.

The Scenario Knowledge Base contributes facts such as "*Blue has a tank battalion, composed of four companies with 14 M1A1 tanks apiece*" and "*Balzer Hill is 2km from Vietti's Farm.*" It also contains diagnostic case fragments that can recognize "*the student positioning tanks on Balzer Hill is evidence in favor of an aggressive attack on the enemy position*" and can recommend partial tutoring scripts such as "*(1) verify the student's situation assessment and rationale, then (2) dwell on time-sensitive aspects of (a) the tactical plan, (b) how the orders were issued communicating that plan, and (c) how the situation was reported to higher command, then (3) transition to discuss the longer-term situation assessment and possible plans.*" These suggestions can be passed on to the Tutor Interaction Module.

The Tutor Interaction Module gets an understanding of possible issues and ways of teaching about them from the Curriculum Knowledge Base. For instance, one curricular point might be: "*Environmental issues put constraints on how effective orders will be.*" The Curriculum Knowledge Base should know that ToF is one scenario that can be used to raise this point, and that in that scenario, the relevant environmental conditions are alertness of crews based on time of day and visibility, current position and activity. It should know that there are a range of general and specific points to make about this issue, including, potentially, anecdotes about how experienced officers have coped with such situations.

One likely way to incorporate lesson-bearing personal anecdotes into the system is to support capture, storage, and playback of desktop video recordings. While this clearly would require augmenting ComMentor authoring tools, from the perspective of our current focus on the knowledge bases, the interesting new requirements have to do with story *indexing*. Indexing is the problem of annotating stories with descriptors so that they can be found when they are relevant to interactions in the tutoring system. Attaching stories to curricular elements is a plausible start at indexing, but some stories can be used in more than one context, while other stories only make sense when some very specific set of circumstances are met. Indexing is thus one of the key issues to be explored as we investigate the possible utility of incorporating war stories into ComMentor.

The Tutor Interaction Module also gets guidance about the application and sequencing of pedagogical techniques from the Instructional Strategies Knowledge Base. This knowledge base can contain general sequencing suggestions such as "*(1) bring student to understanding of a potential problem, (2) solicit possible solutions (3) evaluate and highlight shortcoming of solution (4) iterate on solution, and finally (5) offer model solution.*" It can also contain topic nomination rules such as: "*If the learner made a decision D1 in situation S, and an expert solution for situation S contains a decision D2, a relevant discussion topic is whether D1 or D2 is a better response to situation S.*"

Finally, Figure 6 introduces two feedback paths from the Tutorial Interaction Module back to the DIM. The first path goes through the Session Model, which maintains a history of what has gone on in the current session. It knows what topics have been covered, what issues have been raised, what solutions have been attempted, what instructional interventions have been executed, and what responses have been received. This recent memory must inform the interpretation of student inputs (and down through the pipeline, must affect situation assessment and tutorial actions).

The second feedback path goes through the Student Model, which maintains a longer-term view of what the student is believed to know and not know. For instance, it records in a persistent form what other scenarios the student has been through, what curricular topics were covered (and how they were covered, e.g., were relevant expert stories presented?), and to what extent mastery of those topics was demonstrated. This information is critical not only to biasing assessments of student performance during a scenario, but also to helping the system choose which scenarios would be of value to the particular student.

ComMentor Authoring Tools

We plan to develop an authoring tool for each of the four main knowledge bases as pictured in Figure 6. The Student Model does not need an authoring tool, as it's content is entirely under program control, based primarily on the content of the Curriculum Knowledge Base, with contributions from other knowledge bases as well. We will focus on the Scenario Authoring Tool initially, with a secondary emphasis on the Curriculum Authoring Tool. Over time, effort will shift to the Instructional Strategies Tool. The Domain Authoring Tool will be de-emphasized; for the most part, we expect to provide simple functionality for defining categories and filling in object templates (e.g., vehicles and weapons).

The Scenario Authoring Tool will start by requiring a basic scenario specification, including a scenario name, map, task organizations (with any idiosyncratic supporting icons), and introductory text(s). This basic information provides enough context for the domain expert to begin specifying possible student configurations and sequences—the good and bad cases that will be used to help evaluate students' proposed solutions when running the scenario. Following the lead of other tactical decision ITS projects at SHAI each such case can be constructed using an interface essentially equivalent to the basic ComMentor student interface.

Once constructed, however, these cases must be evaluated, generalized, and annotated. The evaluations indicate the strong and weak points of the proposed partial student solution. Generalizations allow the expert to indicate some aspects of the case pattern that may be varied while still retaining the essential nature (and evaluation) of the situation[4]. Annotations include citations of domain facts and higher-level situation assessments that play into justifying the evaluation of the situation pattern. Among the annotations may be references to elements drawn from the Curriculum Knowledge Base—that is the expert may say that a given case fragment illustrates (or contravenes) a curricular principle. Finally, specific tutoring sketchy scripts—(partially specified) sequences of tutoring actions—can be tied to these cases.

The Curriculum Authoring Tool allows the domain expert to define curricular points (or principles) of the sort that can be referenced by individual scenarios and their diagnostic cases. As is typical of SHAI ITS's, the curriculum can be structured to indicate dependencies (e.g., part/whole relationships as well as logical dependencies). For example, a plausible curricular principle is that you should keep your higher commander informed of important developments of which he may be unaware. Immediately, there arise the questions of what counts as an important development, and what constitutes evidence that the higher commander may be unaware of something. A good understanding of the first principle clearly depends, logically, on an understanding of the later two principles. As with the scenario cases, curricular elements can also have tutoring scripts attached. One particularly important kind of tutoring information likely to be attached here are the war stories referred to earlier.

The Instructional Strategies Authoring Tool is the user interface for specifying generalized tutoring scripts and the recognition conditions that license their application. The basic idea is to pair sketchy tutoring scripts, with student and session conditions. As already

[4] Certain kinds of case sequence generalization were explored and implemented as a core technique in SHAI's Task Tutor Toolkit.

suggested, some tutoring strategies can be triggered more or less directly on scenario conditions (e.g., case recognition), or on curricular conditions (e.g., the need to tutor on a particular point). Authoring of such strategies will be tightly bound to their contexts, and specification of the trigger conditions largely handled implicitly. But we believe there will also be more general triggers for more general strategies—as suggested, for instance by Jona (1995). Work on this tool will dovetail with the important project research focus on identifying and implementing Socratic tutoring strategies (e.g., Task 4 in "Phase II Tasks and Milestones").

Finally, the Domain Knowledge Authoring Tool is likely to be largely limited to elaboration of conceptual taxonomies and the filling in of forms pre-designed to cover important classes of domain entities. For instance, a *vehicle* form might provide places to enter a class (from a pre-existing taxonomy), a range before refueling, a capacity (for people and cargo), a max speed (perhaps different over different classes of terrain), and so on. Exact schemas for classes like vehicles, weapons, etc. may plausibly be derived from existing sources such as the Military Intelligence Data Base (MIDB). We note again, however, that ranges on such values (parameterized by relevant contextual factors) are often more useful and appropriate to support tactical reasoning.

One additional point remains to be made about the enterprise of authoring, and the construction of these authoring tools. Stottler Henke Associates, Inc. has extensive experience with this problem, and an evolving tool set; however, the direct applicability of prior work varies for the different kinds of knowledge. While curriculum authoring is a relatively settled matter, what it takes to author appropriate scenarios and domain knowledge for a given ITS (or for that matter any AI system) is, in part, learned through experience with early examples, and then through additional experience with early authoring tool users. The authoring of Socratic tutoring strategies as already noted, is still a significant research problem, but one that SHAI, in combination with our subcontractor, is particularly well positioned to address. We have structured our Phase II work so that we will get early and frequent experience in both scenario encoding, and domain expert interaction with authoring tools; we plan four waves of authoring tool implementation and observation. One concrete payoff of such experiences is that lessons learned can be rolled into the authoring tools, either through changes in interfaces, or through tailored help systems (or even special authoring tool training systems!).

Future Work

Phase II Plans

Phase II Tasks and Milestones. We propose the following 16 tasks to achieve the Phase II objectives.

1. Perform Formative Evaluation of Phase I Prototype

We will begin our Phase II work by conducting a more complete formative evaluation of the Phase I prototype than was possible within the scope of the Phase I project itself. This evaluation should include hands-on sessions with the system, both for our consulting subject matter experts, as well as for more junior military personnel of the type who would constitute an

appropriate user trainee audience. The object is to observe the sessions looking for aspects of the system that seem to work well, as well as for flaws and limitations. We will also collect the users' comments and opinions, and feed those into our ongoing design and implementation efforts.

2. Identify and Adapt Phase II Scenarios and Plan Tutorial Observation Sessions

Building on our successful approach to data collection on naturalistic battlefield reasoning tutoring, developed during Phase I, we will work with our consultants and subcontractors to select a set of six tactical scenarios, and arrange tutorial sessions with military personnel as students and our consultants as expert instructors. We expect to observe approximately four tutoring sessions per scenario. The bulk of these will be with our subject matter expert consultants acting as instructors. However to broaden our base of observations, we will also intend to run some sessions with alternate instructors. In those cases, we expect to have our consultants act as observers, as a way of gaining additional insight into the session conduct, and as a way to encourage reflection on the ways they conduct their own sessions. The selection of scenarios and generation of a session and observation plan will constitute the first project milestone, to be completed by the end of Month 2.

3. Carry out Tutorial Observation Sessions and Analyze Results

We expect that actual tutoring sessions will be conducted using the distributed approach piloted so successfully in our Phase I work. Members of both the project teams will participate as observers. We expect to begin these sessions perhaps as early as the second month of the project, and project that all tutorial sessions and observations will be completed before the end of year one of the contract.

4. Develop Instructional Strategies Model

One of the major outputs of the tutoring session analysis will be an Instructional Strategies Model. The goal is to establish a solid empirical and theoretical basis for the Instructional Strategies Knowledge Base. We expect the final draft will be produced following the final set of observed tutoring sessions. Generation of the final Instructional Strategies Model will constitute a project milestone, to be completed by the end of Month 13.

5. Elaborate Instructional Strategies Knowledge Base

Elaboration of the Instructional Strategies Knowledge Base will occur in waves (as will be true for the other three knowledge based as well). The first two passes at augmenting this knowledge base will follow completion of the two drafts of the Instructional Strategies Model. Remember, the purpose of the Model in the context of this project is to help us systematically identify and organize our tutoring control knowledge. We have also reserved a block of time and effort towards the end of the project (in Months 19-21) during which we can perform a final reorganization and extension of this knowledge base (and in fact all the knowledge bases) based on what we have learned during the first ¾ of the project, in preparation for the final release and evaluation of the Phase II system.

6. Elaborate Scenario Knowledge Base

The development of scenario-specific knowledge is a top priority in this project. The central contents of the scenario knowledge base will be fragmentary scenario solutions representing good and bad approaches to the problem. Each such fragment will include a set of recognition conditions, as well as a set of belief and rationale statements with indications of how those statements relate to the facts of the scenario, to good domain practice, and to possible tutoring moves. Blocks of time and effort have been scheduled for this task following completion of the three waves of tutoring session observations. As noted later, the second and third of these blocks will coincide with early efforts at developing end-user authoring tools, and will serve to guide those efforts (also note that exercises in the use of the developing authoring tools will follow immediately on the heels of work on scenario knowledge base extension and authoring tool construction). As with all the knowledge bases, there is time reserved in Months 19-21 for a final cleanup and overhaul prior to completing the final Phase II system release.

7. Elaborate Curricular Knowledge Base

This final knowledge base contains information about the principles, concepts, and skills to be taught by the ITS. That information includes interrelationships among curricular items, as well as possible ways to present information about, or probe for understanding of them. Ultimately, the individual student model is formed, in large part, as a reflection of this curricular knowledge base—recording what topics the student has been exposed to, in what form, and with what success. Work on elaborating the curriculum will come in waves, the first three following on efforts devoted to extending the scenario knowledge base. Of course, as usual, one extra block of time is reserved for a final cleanup and overhaul prior to completing the final Phase II system release.

8. Elaborate Domain Knowledge Base

It is critical to have a basic competence for representing and reasoning about the facts of the battlespace, but we intend to limit the effort devoted to stretching that competence. That is because the development of formal reasoning models for such a complex domain is known to be an open-ended (and quite difficult) problem; also, other research programs have focused, and are focusing, on developing such competences. From experience in developing other case-based ITSs, we believe the greatest payoff—in rapid system construction and end-user extensibility—will be achieved by focusing relatively more effort on *scenario-specific* knowledge. That said, we plan to devote some effort early on (during Months 4 and 5) to getting our basic domain model established. We will also devote effort to this task as we approach completion of the second major release of the Phase II ComMentor (during Months 16 and 17). Finally, as with all the knowledge bases, we have reserved a block of time before completing the third and final major release of the Phase II ComMentor system to one last reorganization and extension of the system's domain knowledge.

9. Refine Phase II System Design

From a primary concern with data collection and knowledge codification, we shift here to system design and implementation. Early in the project, based in part on the initial Phase I prototype formative evaluation, we will review the proposed Phase II system design and look for newly uncovered requirements, or opportunities to improve the system. The ultimate result of this effort will be a Phase II design document that will guide subsequent implementation efforts. Generation of this document will constitute a milestone for the project, to be completed by the end of Month 5.

10. Implement ITS Core Extensions

We propose to devote a substantial block of implementation time early in the project to enhance and refine the basic system code originally developed for the Phase I prototype, in keeping with the dictates of the newly refined Phase II system design. The object is to provide a firm foundation for a more functional, scalable and robust system. This overhauled system base, combined with expanded knowledge structures and a first pass the authoring tools will constitute the first Phase II release of ComMentor.

11. Explore Alternate Interaction Mechanisms

As part of the work on the second Phase II ComMentor release, we propose to experiment with a range of alternate interaction mechanisms. Two major examples cited above include: (1) implementing a capability to capture expert anecdotal "war stories," and then effectively deploy them during tutoring sessions; and (2) implementing a capability to manage tutorial input and output in the form of speech. For the "war stories" effort, we intend to draw on earlier work, primarily at Northwestern's Institute for the Learning Sciences, on conversational video archives. For the speech input/output work we intend to draw on ongoing efforts at SHAI's Seattle office on robust speech processing for training applications.

The introduction of new interaction mechanisms such as these has implications for the authoring process, and we expect to see that reflected in the later waves of authoring tool development. We class these extensions as experimental because they require substantial implementation (and ultimately authoring) effort, and there exists, as yet, relatively little experience with how to most effectively integrate such capabilities with ComMentor's style of tutoring. Achieving adequate performance, appropriate forms of integration, and efficient authoring constitute technical research topics

12. Implement Authoring Tools

The development of end-user authoring tools will constitute a significant thrust of this project and will be spread over all three releases of the ComMentor system. Early on, we expect to focus on helping to capture scenario information. Over time, we will aim to extend the authoring tool's coverage to include curricular knowledge (including war stories), and instructional strategies as well. Our domain expert consultants will contribute to this effort

through their comments on proposed design, and through participation in the authoring tool application exercises described in the next task.

13. Observe subject matter expert (SME) Use of Authoring Tools

Following each wave of authoring tool construction we will devote a slice of time to observation and reflection on how those tools are used by our consulting domain experts. The idea is to ensure that the tools we build are usable by their intended audience, and to learn what is working and not working as quickly as possible. The final set of these observations is expected to occur just before we begin our final evaluation studies. Our intent is to have our domain experts make an effort to enter one or two new scenarios using the final versions of the authoring tools, and to include these new scenarios in the final evaluation to compare their effectiveness to the other, more painstakingly analyzed and encoded scenarios.

14. Evaluate Phase II System Releases

In keeping with our iterative development approach, we aim to interleave evaluation (and possible course corrections) into all the cycles of our work. To mark the end of the first two ComMentor release cycles we plan to perform interim evaluations of the system. These evaluations will involve use by representatives of the system's intended audience. Initially formative in character, the evaluations will transition to summative, culminating in a final formal evaluation of the third release. The two interim evaluations under this Task will serve as milestones, marking the completion of release cycles 1 and 2 by the end of Months 10 and 17 respectively.

To mark the end of the final ComMentor release cycle, we will perform a full, formal evaluation of the system, as used by representative members of its intended user population. Planning for this evaluation will begin as early as Month 4. We expect to adapt and apply the battlefield reasoning evaluation metrics we understand to be under development by ARI in support of TLAC. Completion of this study by the end of Month 23 will mark the project's penultimate milestone.

15. Analyze System's Long-Term Deployment Issues

In order to provide as complete a picture as possible of ComMentor's utility, we propose to devote time at the very end of the project to identifying, and, as far as is possible, quantifying, the likely costs and benefits of deploying the system and maintaining it over the long haul. The object is to get a clear vision of the road to Phase III adoption of and wide-spread use of this work.

16. Prepare Final Technical Report

In the last month of the project we will write up our results in a final technical report, documenting our efforts and accomplishments. Completion of this report by the end of Month 24 will mark the final project milestone.

Phase III Transitional Plan

At the end of Phase II, we expect to have developed:

- A catalog of instructional strategies that can be employed to support Socratic interactions for battlefield command reasoning and for other similar learning domains.
- A knowledge representation design for tactical scenario facts, scenarios, and analysis that can be used to support an intelligent tutoring system.
- A scenario-based intelligent Socratic tutoring system that provides mentor-student interactions to teach battlefield command reasoning skills.
- An application-specific authoring tool emphasizing creation by subject matter experts of new teaching scenarios comprised of tactical scenarios along with "good" and "bad" solutions.

The Phase II research and development will provide a solid foundation for Phase III commercialization in four ways. First, we will have a reasonably complete catalog of Socratic tutoring strategies, and experience implementing many specific tutoring techniques. Second we will have experience building and evaluating a complete Socratic tutor aimed at high level reasoning skills—a first in the field. Third, we will have a working system that actually teaches battlefield reasoning skills using a limited number of cases, and the authoring tools to help grow the system cost-effectively. Finally, we expect to have the interest and attention of relevant part of the DoD training community. We believe our Phase II system will be compelling to a wide range of potential customers, not the least of which would be training organizations within DoD.

Possible Markets for High-Level Socratic Tutors

The proposed research presents enormous commercialization potential. Web-based training offers the promise of providing training "any-time, any-place." However, current web-based training technologies frequently focus on teaching facts and procedures rather than reasoning skills and thinking habits. We believe that enhanced ITS technologies that teach reasoning skills will be of tremendous value to both government and commercial customers.

Consider a key example, already introduced above. Stottler Henke Associates, Inc. is currently working with Simulation, Training and Instrumentation Command (STRICOM) to develop the command, control, communications, computers, intelligent tutoring system (C4ITS) for the Armor Captain Career Course (a course, incidentally, open to many officers who are not strictly Armor Captains). We expect the reasoning skills orientation and Socratic tutoring capabilities of ComMentor to form a tremendously useful adjunct to the more traditional scenario-enactment training orientation of C4ITS. We believe that a combined system would find a very receptive audience, and hope for a clear path to fielding a full-scale implementation.

In general, we plan to use the reasoning skills ITS technology developed during this project to offer the following software products and services:

- Technology-enabled consulting services to help web-based education service providers offer reasoning skills tutoring systems. Potential targets include providers of paper-based

case teaching materials who are starting to offer software tutors (e.g., Harvard Business School Press), and on-line providers of learning software for K-12, university, and graduate school-level programs.

- Technology-enabled consulting services that deliver turnkey ITS applications for large, end-user companies with sophisticated training needs.
- Tutoring system engines and authoring tools to consulting companies who provide sophisticated training solutions to large companies. For example, Andersen Consulting applies authoring tools developed by its partner, the Institute for the Learning Sciences, to develop intelligent tutoring systems for its clients.

SHAI's Market Development Capabilities

We have identified intelligent tutoring systems as a strategic direction for the company. Although many companies are using the Web to facilitate communications among students and educators or to simplify access to traditional, electronic course materials, no companies yet offer or provide a vision for web-enabled intelligent tutoring systems. We believe that intelligent tutoring systems are essential for enabling web-based learning systems to achieve the vision of helping students learn "any time, any place." To position ourselves for this important market we are undertaking much of our development effort using the Web-friendly Java programming language.

We will focus our marketing efforts on consulting services provided to educational software providers, consulting companies, and early-adopter end user companies. We will sell these services via direct consultative sales to identify custom software solutions that support those customer's unique needs. These sales activities will be supported by a combination of marketing and lead-generation activities including direct mail, presentations at educational industry events, and articles. For example, during the year 2000, SHAI delivered presentations describing intelligent tutoring systems technologies and benefits at the Interservice/Industry, Simulation and Education Conference (I/ITSEC) 2000 (three presentations), American Society for Training and Development (ASTD) TechKnowledge 2000 conference, and the SmartSystems conference sponsored by NASA and other organizations. During the year 2000, we wrote (or helped write) articles that appeared in the ASTD LearningCircuits electronic magazine for technical training (http://www.learningcircuits. org/feb2000/ong.html) and the San Jose Mercury News.

The STRICOM relationship highlighted above is an example of a marketing opportunity that could be an early route to turning the results of this research and development project into a production system. Similar positive relationships with the Navy's Surface Warfare Officers School (a legacy of the tactical action officer [TAO]-ITS project) could serve a similar end. Both would be examples of technology-enabled consulting that delivers turnkey ITS applications for end-users with sophisticated training needs.

Through government-funded and commercial software development projects, SHAI has amassed significant expertise and software assets, which make us technologically competitive with the small number of potential ITS competitors. We currently have on-going software consulting relationships with major educational software/content vendors, and we are confident

of our ability to establish new relationships with a wider range of software/content vendors in other educational markets to disseminate SHAI's ITS technology through established (or rapidly growing) product vendors. Likewise, we have a growing network of satisfied customers throughout the DoD world.

Stottler Henke Associates, Inc. has the resources and expertise to support the sales and business development effort required to pursue direct sales of technology by enabling consulting projects and licensing arrangements to end-user companies, other vendors, and consulting companies. Stottler Henke Associates, Inc. continues to augment its business development staff and budget to exploit commercial product and consulting opportunities. For example, James Ong serves in engineering management and business development roles at SHAI. Before coming to SHAI, Mr. Ong was the director of product marketing at Belmont Research, Inc. and led the commercialization of the TableTrans® data transformation system, developed with partial funding from the National Institute of Standards and Technology (NIST) Advanced Technology Program (project 94-04-0024: "Voyager: Browsing and Automatically Extracting Healthcare Data from Scattered Databases"). TableTrans was selected by NIST as a NIST/ATP success story (http://www.atp.nist.gov/atp/success/belmont.htm) and is co-marketed by IBM to pharmaceutical companies to streamline clinical data handling.

Conclusions

During this Phase I SBIR project we accomplished several important goals. First, we developed a deep understanding of the battlefield command domain, and of existing techniques for training battlefield command reasoning skills. What we learned reinforced the importance of making Socratic tutoring more widely available to commanders-in-training, and suggested that the TDG format was an effective context for such training. We identified a range of levels at which such tutoring could be conducted, and we experienced first-hand the importance of getting good data on which to base the design of an automated tutor.

Driven by this initial survey, we conducted six sample tutorial observations. These observations served as the basis for developing an initial taxonomy of tutorial moves. Our taxonomy encompassed scenario-based Socratic tutoring moves, general topic management moves, specific theme-related tutoring moves, and a variety of tutoring moves associated with styles of tutoring other than what is classically considered "Socratic."

Based on our domain understanding, and our tutoring observations and analysis, we designed and built a limited proof-of-concept prototype of the ComMentor automated Socratic tutoring system. The point of the prototyping effort was to help advance our design ideas through experimentation, and to demonstrate some of the key ideas and technologies that would go into a complete Phase II prototype. We demonstrated a capability for multi-modal input and output (graphics and text) including parsing of moderately complex and variable natural language orders. We demonstrated an initial capability for the tutoring system to pursue gaps in student inputs, and to classify proposed student problem solutions into categories that could drive the tutoring session forward by working through thematically scripted interactions that nonetheless maintained sensitivity to the student's inputs. All of this was built to function in the context of a tutor goal-management mechanism, and a general scenario-based tutoring cycle that

showed how techniques other than Socratic tutoring could be combined (e.g., closing prompts intended to facilitate student reflection).

Finally, we incorporated lessons learned from our Phase I prototyping effort into a project plan and system design for a Phase II effort. We believe we have developed a system design and a project work plan that will use the available resources to significantly advance the state of the art with respect to automatically tutoring high-level command reasoning skills. That plan includes full-scale prototype implementation of the ComMentor system with approximately six scenarios, and an accompanying suite of authoring tools. It also includes evaluation studies to assess how well the system functions. We believe our Phase II plan, as well as our other corporate experiences and contacts, will position us to take the results of a Phase II effort on to successful Phase III commercialization. The technologies to be developed here will provide a significant increase in the capability of ITSs, while lowering the costs of fielding such systems.

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Appendix A

Related Work

ITS Research at SHAI

AEGIS Tactical Action Officer ITS

Stottler Henke Associates, Inc. has developed for the U.S. Navy a simulation-based Intelligent Tutoring System (ITS) which enables students to act as tactical action officer (TAOs) in tactical simulations. The simulation's graphical user interface displays a geographical map of the region and provides rapid access to sensor, weapon, and communication functions. After the student completes a scenario, the ITS evaluates the entire sequence of student actions to infer tactical principles that the student correctly applied or failed to apply. These principles are detected according to sophisticated pattern-matching algorithms defined by the instructor using the System's graphical user interface. The system is highly configurable within the domain of naval tactical simulations, and authoring tools enable the instructor to define new types of ships and aircraft, scenarios, and principles. The instructor can also define complex behaviors for each friendly and enemy ship and aircraft to create realistic, intelligent, multi-agent simulations. The TAO ITS has proven an effective training tool. Tactical action officer students at the Surface Warfare Officers School are currently using it, and initial independent evaluation of the software in use has been highly favorable. Simulation-based intelligent training systems complement traditional classroom or computer-based training by enabling students to practice the application of concepts and principles. Additional funding has been received to adapt the TAO ITS for fleet use on board ships. Contact: Joe Russell (703) 602-5959 x183.

C4I ITS

Under contract to STRICOM, SHAI is currently developing C4I ITS, a prototype intelligent tutoring system for armored and mechanized infantry company commanders. The C4I ITS will teach tactical decision-making, command and control principles, and the use of the Force XXI Battle Command, Brigade and Below (FBCB2) command and control system. Before each mission, students will issue pre-mission orders and graphical overlays that specify movements. The tutoring system will assess these plans using symbolic pattern recognition techniques that compare each student's plan with annotated good and bad plans (or portions of plans) supplied by experts. Similarities between the student's plan and the good plans will identify specific proficiencies in high-level and low-level skills. Similarities between the student's plan and bad plans will identify skill deficiencies.

During the mission, the students will interact with FBCB2 and Spearhead, a military game simulation program that is being adapted for use in military training and is being integrated with FBCB2. Spearhead implements the simulation behaviors and presents a 3 dimensional "out the window" view of the world as seen from each vehicle. Spearhead will exchange real-time simulation data with FBCB2, and C4I ITS will intercept those packets. The tutoring system will construct scenarios and modify scenarios in progress to include situations that test various

situation assessment skills. For example, the tutoring system could place friendly forces in certain locations that the student might otherwise fire upon. If the student does fire upon those positions, the tutoring system can infer that the student failed to use FBCB2 to notice the presence of friendly forces in that area. As another example, the tutoring system could place enemy forces at a location such that the student should direct friendly forces to oppose them. Failure to perform this action indicates either a lack of situation awareness of the enemy forces, or a poor tactical decision. Contact: Rodney Long at STRICOM, (407) 384-3928.

Internet Intelligent Tutoring System Authoring Tool

In connection with a project to make ITS systems more easily distributed over the Internet, as well as allowing separate ITS systems to interoperate, SHAI is developing an authoring tool—IITSAT—that addresses several of the authoring tool needs identified for ComMentor. In particular IITSAT provides for the authoring of curriculum knowledge as hierarchies of principles to be taught, and that can be interrelated, in addition, by prerequisite annotations. In IITSAT, principles have multimedia courseware attached, and can be linked to scenarios that rely on those principles, as well as to specific critiques that determine when a principle is being followed or violated. In ComMentor, curricular elements will be linked to scenarios and cases (critiques), but instead of multimedia courseware, we will be concerned with alternate forms of instruction, such as tutoring moves and expert stories. IITSAT provides an API to plug in custom scenario authoring tools (since scenario structure vary radically across domains), and provides a first instance of a critique authoring tool. The ComMentors scenarios, with their good and bad cases will fill these niches. Finally, IITSAT contains an Instructional Methods authoring component. However, unlike ComMentor's proposed Socratic methods, IITSAT focuses more on simpler techniques to adapt instruction to individual students (e.g., how many exercises to give on any given topic, how quickly to give hints, how many, and what type of examples to provide, etc.).

Speech Interaction for ITSs

Stottler Henke Associates, Inc. has been tasked by the Navy, in a project sponsored by the Office of the Secretary of Defense, to develop an innovative system that will advance the state-of-the-art in computer application support for natural speech dialogue. The design of this system ties together the best of the current research in speech recognition, natural language understanding, and dialogue modeling, together with an eclectic combination of supporting Artificial Intelligence techniques, into a complete end-to-end design. In our Training Application Language Kit (TALK) architecture, all components in the natural speech dialogue system will provide disambiguation and validation for the output of the others. In addition, all components will operate using a shared set of resources, including a representation of the current dialogue context, generic and domain-specific dictionaries, and dialogue models. Sharing these resources between the components of the TALK model not only ensures consistency in the interpretation and generation of natural speech dialogue, but also provides an unprecedented capability for training the system for new domains and integrating dialogue capability into a wide range of applications, such as instructional systems and automated customer support. Phase I of this Small Business Innovation Research (SBIR) program began on January 26, 2001. Client: NAWCTSD, Orlando, FL. Contact: Steve Slosser, (407) 380-4599.

Dismounted Infantry Military Operations in Urban Terrain (MOUT) Intelligent Tutoring System

Stottler Henke Associates, Inc. developed, in cooperation with Research Development Corporation, a simulation-based ITS (SITS) for training dismounted infantry, both as individuals and teams, that would be used with a virtual reality simulator. Included in the project was the development of a generic automated training system (ATS) architecture that can interface with existing and future simulators. The SITS diagnoses student learning needs, determines what instruction content and technology are most appropriate, and drives the presentation of that instruction. Key technologies are case-based reasoning (CBR), integrated knowledge structures for representing expert and student knowledge, automatic knowledge elicitation, and dynamic scenario selection and creation. The architecture supports automatic and semi-automatic knowledge engineering to update its knowledge base as the domain itself evolves. The system trains squad and fire team leaders in Military Operations in Urban Terrain. The ATS monitors the student's actions in the virtual reality environment, assesses his deficiencies, and modifies the scenario or creates new ones to address those deficiencies. A CBR system also selects the most appropriate instructional technique based on the student's individual requirements and past learning behavior.

Constructivist Distance Learning System for Counter-Terrorist Intelligent Analysis

Stottler Henke Associates, Inc. is developing for the U.S. Army at Fort Huachuca a training system comprised of two parts. The first is a general framework that supports the creation of Constructivist distance learning (DL) courseware in a wide variety of areas. The second product is the Intelligence in Combating Terrorism (ICT) Tutor, a specific tutoring and scenario authoring system built using this general course creation framework.

The purpose of the ICT Tutor is to give students extensive, hands-on training in the analysis of raw intelligence information about terrorist organizations and installation threat assessments, leading to a compact summary of a terrorist operation and an assessment of the current level of threat. The tutor uses Constructivist learning theory by supporting adaptive learning, modeling, intentional activity, and rich scenario contexts. Contact: Helen Remily at (520) 533-9077.

Task Tutor Toolkit and Remote Payload Operations Tutor for Procedural Training

To lower the cost and difficulty of creating scenario-based intelligent tutoring systems for procedural task training, SHAI developed the Task Tutor Toolkit (T^3), a generic tutoring system shell and scenario authoring tool. The Task Tutor Toolkit employs a case-based reasoning approach where the instructor creates a procedure template that specifies the range of student actions that are "correct" within each scenario. The system enables a non-programmer to specify task knowledge quickly and easily via graphical user interface, using a "demonstrate, generalize, and annotate" paradigm that recognizes the range of possible valid actions and infers general principles that are understood (or misunderstood) by the student when those actions are carried out. The annotated procedure template also enables the Task Tutor Toolkit to provide hints requested by the student during scenarios, such as “What do I do now?” and “Why do I do that?” At the end of each scenario, Remote Payload Operations Tutor (RPOT) displays the principles

correctly or incorrectly demonstrated by the student, along with explanations and background information. The Task Tutor Toolkit was designed to be modular and general so that it can be interfaced with a wide range of training simulators and support a variety of training domains.

Stottler Henke Associates, Inc. and NASA used the Task Tutor Toolkit to create the RPOT, a tutoring system application which lets scientists who are new to space mission operations learn to monitor and control their experiments aboard the International Space Station according to NASA payload regulations, guidelines, and procedures. Contact: Mr. Stephen Noneman, (256) 544-2048. Phase II Completed: February 2000.

Intelligent Tutoring System for Long-Range Acoustic Detection of Submarines

Stottler Henke Associates, Inc. is developing for the U.S. Navy an *Acoustic Analysis Intelligent Tutoring System* (AAITS) which will enable students to practice the detection and classification of sources of underwater acoustic signals such as submarines and whales. Acoustic analysis experts will create scenarios using a Scenario Authoring Tool by selecting and viewing LOFARGRAMs which are frequency-analyzed acoustic datasets displayed as 2D images, annotating them with significant features and links among related features, providing reasons for requesting each LOFARGRAM, and assigning a final classification. Students will use the Tutoring System to carry out this same acoustic analysis. By comparing the details of each student's analysis with those of the expert, the Tutoring System can identify the acoustic analysis principles understood and correctly applied by each student, provide specific and individualized feedback, suggest relevant training materials, and select appropriate next scenarios. By storing LOFARGRAMs annotated by experts, AAITS also serves as a knowledge repository which disseminates the most current acoustic analysis expertise to sonar technicians on land or at sea. A key innovation of AAITS is the use of an application-specific Scenario Authoring Tool that enables experts to create scenarios, which encode their expertise and analyses intuitively, by annotating datasets graphically, using a point-and-click graphical user interface. Phase II project start date: February 1999. Contact: Master Chief Joseph Spivey at SPAWAR, (858) 537-0312.

AI Representations of Military Plans and Tactics at SHAI

Stottler Henke Associates, Inc. has developed several systems which employ artificial intelligence representations of military plans and tactics. Selected projects are described below.

Intelligent Control for Immersive Wargaming

Stottler Henke Associates, Inc. is developing a wargaming system to fuse entity-level control with aggregate-level command to manage a small-scale air campaign. The Phase I prototype does this by combining an entity-level robotic control architecture called Hap, based on research at Carnegie Mellon University, with a strategic command system. The system allows simulation participants to interact with intelligent allies and enemies. For example, if there is a goal to destroy an enemy airbase, the aggregate-level command will generate plans to form a strike package. Entities controlling the elements (fighters, ECM, and ground attack) coordinate together to rendezvous outside enemy airspace, form the strike package, and overcome enemy resistance in a team-oriented fashion. This current project was started in May

1999 and the contact is David Ross at Air France Research Labs (AFRL) Rome Laboratories - (315) 330-7624.

Multi-User Simulation Environment (MUSE)

Our Phase I prototype dealt with the need to intelligently control all the tactical platforms in a scenario. We developed a schema for military warfare tactics representation and execution in MUSE using expert system and graphical techniques to capture the human decision processes. Agents in the scenario would compute intercept paths to engage enemy aircraft. The networked prototype ran with geographically distributed team players, both human and artificial. Phase I was completed in December of 1998 and the contact is Terry Jackson at AFRL Brooks AFB - (210) 536-3908.

Robustness in Air Campaign Plans

One important attribute of air campaign plans is robustness. How successful will a plan's execution be in the presence of uncertainty and changes, and how hard is it to change the plan once execution has begun? Military planners can gauge the robustness of air campaign plans. Furthermore, plans produced by automatic planners tend to be graded poor on this scale. A team of cognitive psychologists worked to unravel and understand the thought processes involved. Stottler Henke Associates, Inc. was tasked with analyzing this abstract body of work, developing computable concepts which parallel these processes, implementing them, and interfacing them to a planning system in current use. This work involved an understanding of the entire planning process from the highest level to the most detailed. Client: Klein Associates. Contact: Dr. Tom Miller, 513-873-8166. Completion Date: September 1997.

Related Work by Others

Mixed Initiative and Socratic Tutoring Systems

Research in mixed-initiative and Socratic tutoring systems has been carried out for more than 30 years. In fact, much of the early work in intelligent tutoring systems focused on the support of dialogs between the software and the student. Early work includes the Scholar system that taught South American geography (Carbonell, 1970). It is significant in its early use of domain knowledge representations (about geography) that are separate from the instructional decision-making knowledge. However, this system taught facts about geography rather than reasoning skills and therefore did not pursue many goals typical of Socratic dialog. Collins (1976) developed a set of two dozen decision-making rules used by Socratic tutors and embodied these rules within the WHY system that taught meteorological reasoning about rainfall processes. Clancey (1987) developed GUIDON, a tutoring system for diagnosing blood diseases that used as its expert model the Mycin rule-based expert system. A finding of the GUIDON project was that expert system rule-bases frequently employed reasoning methods (in this case, rules) that were not intuitive when used to generate tutorial dialog utterances. Edelson (1992) describes Socratic tutoring in the domain of biology that relies on a case-base for its expert model.

This previous work provides useful findings and insights, especially in the identification of tutoring strategies, and we expect to build upon this prior work. However, ComMentor will require advancements in the areas of using complex plans and rationale structures supplied by experts as the basis for tutoring dialogs; using multiple expert solutions for assessing student solutions; and assessing and enhancing high-level thinking skills and habits as opposed to detailed knowledge and lower-level reasoning skills.

Intelligent Tutoring System Authoring Tools

The ITS technology has been under development for over three decades by researchers in education, psychology, and artificial intelligence at military and academic research labs. Research studies carried out so far show that students taught using ITSs generally performed better and learned faster, compared to classroom-trained students. However, a major impediment to the widespread use of intelligent tutoring systems is that they frequently require custom software development and are therefore expensive to create. Consequently, the development of authoring tools to enable lower-cost development of these tutoring systems is also an area of active research.

Much of the prior research in ITS authoring tools has been in support of procedural task training domains where there is a "correct" method for carrying out each procedure. Guralnik (1996) describes an authoring tool which applies a content theory of task knowledge which enables the tutoring system to generate replies to important questions from the student, such as "What do I do next?" and "How do I do that?" (Munro & Pizzini, 1995) describes the RIDES system, which enables authors to create graphical training simulations (frequently, of devices) integrated with the intelligent tutor.

The ComMentor will require a new type of ITS authoring tool, one that captures the reasoning of experts in support of solutions, even when there is no single correct solution. We expect that ComMentor may draw upon prior research in ITS authoring tools, but ComMentor will require significant advances in the capture and application of knowledge structures that capture the expert's scenario-specific reasoning.

Goal-based Scenarios, Problem-solving Architectures, Generic Tasks

Learning different types of problem-solving tasks will warrant different types of tutoring system architectures. However, we believe that there are a manageable number of distinct types of abstract problem-solving tasks. We are encouraged and inspired by research in Generic Tasks (Chandrasekaran, 1987), Components of Expertise (Steels, 1990), and Goal-based Scenarios (Schank, Fano, Bell & Jona, 1994), who all argue that the number of types of problem-solving skills is quite finite. Proponents of Goal-based Scenarios at the Institute for the Learning Sciences (ILS) at Northwestern University assert that:

- Students learn effectively when they are pursuing goals within the simulated scenarios, and,

- One can categorize goals into a small number of abstract types (e.g., Investigate and Decide, Run a System or Organization, Pursuade, etc.) which strongly affect the architecture of the appropriate tutoring system.

Our proposed project team includes Dr. Eric Domeshek, a project manager at SHAI. Before coming to SHAI, Dr. Domeshek taught and carried out research at ILS where he developed a pair of successfully fielded educational systems for university courses, as well as several other AI and multimedia systems for knowledge management. One of these systems, named "Invitation to a Revolution," implements a Goal-based Scenario (Pursuade) to help students understand the social forces that shaped France just prior to the Revolution. The software includes a hypermedia database of over 290 video clips (over 4.5 hours total) of experts, as well as 229 clips of 12 different historical characters which support simulated conversations between the student and those characters.

Appendix B

"Tanks On the Farm" Sample Session Transcript

Problem

The following table represents a transcript from one of our Phase I instructional observations. The first column of the table contains timing information and comments inserted by the session analyst. The second and third columns represent the text of utterances made by the Instructor and Student respectively. Column four is a first pass at categorizing the type of interaction contained in a given row of the table. Column five is a similar attempt to discern what triggered a given utterance by the Instructor. Columns six and seven tag each instructor utterance according to the instructional theme being addressed (based originally on the TLAC themes), and what level of scaffolding is being exhibited (based originally on the TLAC-related scaffolding levels discussed in the body of the report).

In all, we held six sessions like this one, three of them devoted to the "Tanks on the Farm" problem. This transcript represents a relatively high level of performance by the student. It was used, along with the other two "Tanks on the Farm" transcripts, as a central resource in preparing the Phase I prototype and demonstration scenario.

Vignette	Tanks on the Farm (Phase I, Session 1)					
Date/Time	18 April 2001, 1500					
Student	Duck					
Instructor	Hannibal (Wolfpack adds at end)					
Analyst	RPD/Wolverine					
Comments	Based on notes and CD audio recording. Instructors classified this session as HIGH-LEVEL PERFORMANCE.	Key learning points of Tanks on the Farm: Primary-Timing; Big Picture; Secondary-Clarity of Orders; Cdrs Intent not just specific orders; Visualization. Instructors classified this session as HIGH-LEVEL student performance.				
Time/ Comments	**Instructor to Student**	**Student to Instructor**	**Type of Interaction**	**Trigger**	**Theme**	**Scaffolding Level**
1321 Analyst comment: Student was not directed to take notes or provided with paper copies of anything.	(Not captured on audio recording) I'm going to start the Decision Making Game (DMG). I will not be asking you to do anything. At any point you can tell me to stop when you are ready to decide or make any other action. Otherwise, I'll continue to develop the situation.		Statement (S): Instructions on student and instructor roles and behaviors.	Script		
	FR (Friendly Forces) and EN (Enemy) organization given (Not entirely captured on audio recording). Audio starts: Intelligence estimates that 10 Bde is at about 80% strength; that 20 Bde is between 50 and 75% strength. So that's the situation on 6th Division. Any questions about those guys?		Statement (S) of the problem: information re EN (IF).	Script		
		Negative.				

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
Analyst note: Student should have a button or paper available to check the EN and FR organizations and to look again at mission and at Cdr's intent as desired.	Good. OK. So, after having been pulled out of action about two weeks ago for refitting, your Bn is now once more near full strength. You're making a night administrative move on improved roads to your new Assembly Area (AA) in Viettiville. Viettiville as you can see is about 8km northeast of the map here. That's where your AA is going to be. You're making a night administrative move to Viettiville where you will be part of the Div reserve.					
	The front as you can see is about 10-12 km to the east of the east edge of the map sheet here. So, in other words, the front is 10-12 km east of where we are. Viettiville is about 8 km northeast of where we are. During the move you are instructed to observe radio listening silence. The EN has been attacking generally from the east with Armor and Mechanized Infantry usually leading with a Bn of tanks preceded by a reconnaissance Co. That reconnaissance Co will be operating on one or more axes depending on the terrain in front of the tank Bn.		Statement (S) of the problem: information (IF) re Friendly Forces (FR), the situation and Cdr's intent.	Script		

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
	But then you are contacted on the radio by a section of LAV 25s performing rear area security. They have passed you only a few minutes ago on the road and are now in Balzerton. The Light Armor section leader makes the following report. He says, "I count about 25-30 T72s. I say again T72s at Vietti's Farm. They are apparently laagering. I see some dismounted crews. I see a pair of T72s, apparently scouts, approaching Balzer Hill from the east. They'll be in position to see you in less than five Mikes [minutes]. I spot a convoy of trucks, about a half a dozen including two refuelers, approaching the farm on the Viettiville road about 3 klicks [km] from the farm. I am unobserved at this time." The section leader's voice is urgent, but not panicked. He seems sure of what he sees. You're continuing to move in your march column toward Balzerton.		Statement (S) of information (IF) in the form of a spot report: Probe to stimulate student behavior.	Instructor assesses the student's initial overview of the situation and COA. Purpose is to see what student's "hypothesis" about the situation, to look for mistaken assumptions student holds, E26and gaps in student's thinking vis-a-vis themes, basic information, situation specific information.		Level 2 - What does the order look like?
1527/ CD 03:40		Ready to make a decision here.				
	Alright, what's it going to be?					

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
		LAV section, once you see my attack taking off, I want you to support our engagement by engaging those two T72s moving up in the vicinity of (VIC) of Balzer Hill. Alpha Co I want you to come off on LAV section's right flank to take out those two T72s and continue your attack at the EN's laager site, VIC Vietti's farm. Bravo and Charlie Co I want you to move up VIC Balzer Hill and attack the EN's laager site from VIC Balzer Hill . You all will kick off this attack. Your firing from Balzer Hill will kick off the attack. You will be engaging the EN force laagering at Vietti's Farm. Delta Co follow in trace of Alpha Co. You will be my reserve. TOW section I want you to move out to the trail that leads up to Viettiville to the north. Defend that trail to defend our company's left flank.				
	Is that it?					
		That's it.				
1530/ CD 04:56	Now why don't you go ahead and diagram that for us real quickly here?		S: Student instructed to also make map input.	Script?		
CD 05:48 Student concludes map input.		How's that, Sir?				
	Fine, so give me your thought process. What's the story here. What are you thinking about the situation and why are you doing what you are doing?		Q: Probe overall thought process.	Deepen on initial overall hypothesis so Instructor knows where to go next.		Level 1-What does the student know and need to know?
1331/ CD 05:58		OK. In five minutes, he should be able to see me.				

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
	Who is?		Q: Clarification of Input.		T2 EN model	Level 1- What do you know?
		These EN T72s that are approaching VIC Balzer Hill. [EN] is in a laager site at Vietti's Farm and I have the opportunity to get the jump on them. I'm sending the TOW section up to the trail to the north as an economy of force measure just in case I'm getting some kind of surprise from the north.				
	OK. So they're protecting your Bn left flank against anything coming down that trail from Viettiville?		Q: Clarification of Input to probe Assets and EN model.		T4 Assets and T2 EN model	Level 1-What does the student know and need to know? Clarifying assumptions.
		Yes, Sir.				
	OK. So why are your worried about that?		Q: CIN	Instructor may not be sure what cue or rule that student might be using to make this decision.	T4. Assets and T2 EN model	Level 1 -What does student know?
		I'm not so much worried about that as the fact that I've got an asset that I'm not employing and I can use that to protect my left flank.				
	OK.					
		By the looks of it, I can range the laager site from Balzer Hill with the M1s. Looks like it's going to be about max range for the M1s.				

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
	Right. So what's the significance of that, if anything?		Q: Probe understanding of sub problem.	Student made an observation about assets without an inference.	T4 Assets and EN model	Level 2 - Options
		Well, if there is something past Vietti's Farm that we haven't noticed yet, I'm not going to be able to range that.			T8 Visualization of fight after the fight (introduced by student)	
	OK. But you're not concerned about that at this point?		Q: Probe for understanding of follow-on forces.	Student mentions follow-on forces.	T8 Visualization	Level 2
		I'm not.				
	OK. So the idea is that Bravo and Charlie are in a position to do significant damage to this EN force in VIC Vietti's Farm?		Q: PRD Assets.	Instructor returns to T4 Assets.. Assesses that student is not ready to move to visualization of fight after the fight subproblem?	T4 Assets	Level 2
		Check, Sir.				
	And, did I understand that Alpha Co is going to be conducting a maneuver attack against Vietti's Farm from there? (refers to map)		Q: PRD Assets and CIN.		T4 Assets	Level 2 - Options

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
CD 07:33		No, Sir. They're coming up on line with the LAV section supporting Bravo and Charlie's attack on Vietti's Farm from their position there.				
	So they're also supporting by fire, but they're not maneuvering against them?		Q: PRD Assets.		T4 Assets	Level 2 - Options
		Right, Sir.				
	So what you've got basically is a three Co. attack by fire against what?		Q: PRD Assets.		T4 Assets and EN model	Level 2 - Options
		Against the EN's laager site VIC Vietti's Farm.				
	What's at the laager site? Your estimation?		Q: Look at Assets from view of EN model.	Student mentions EN within current subproblem.		Level 1- What does the student know?
		I've got approximately 30 vehicles probably preparing for some form of offensive maneuver.				

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
	Give me your assessment of what you think is going on here with Red. What's the Red story? What are they trying to do? What do you anticipate is likely to happen next?		Q: EN model and Visualization.	Script? Satisfied he has the student's initial hypothesis about the situation well understood? Instructor transitions to building on themes starting with EN model.	T2 EN model (Level 4)	Level 2 What is going to happen next?
		Based on what little I know right now, seems like he feels relatively safe right where he is. Two T72s approaching Balzer Hill. Reconnaissance element isn't all that far out from his laager site where he's presumably in an assembly area. I would imagine he is preparing for some form of offensive operation, but it's not going to happen anytime soon, because from what I can gather, he doesn't have too much reconnaissance out forward.				
	So your estimation is that he's just getting settled in here at Vietti's Farm?		Q: PRD EN model. Level 3 prediction of EN behavior.	Need to deepen on EN model because student is missing cues and thinks offense won't kick off soon.	T2 EN model (Level 4 prediction of EN behavior.)	Level 1. What does student know?
		Yes, Sir.				

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
CD 09:15	And your rationale for that is....?			Student EN model is wrong. He does not perceive threat, is refueling, and will be on the move again as soon as he can. Looking to see what cues he is perceiving.	T2 EN model (Level 4 Prediction)	Level 1. What does student know.
		Well, the fact that he doesn't have reconnaissance out there much farther. He was pressing forward in say the next 6-12 hours, I would think I would have run into something by now or he would have reconnaissance farther to the south.				
	To the south? Why to the south?		NA			
		Correction, farther to the west.				
	So you think this guy's making a east to west move?		Q: CIN EN model.	Student makes prediction of EN behavior.	T2 EN model (Level 4 prediction of EN behavior.)	Level 1. What does student know.
		Right, Sir.				
	And he's using Vietti's Farm as AA?		Q: Probe EN model.		T2 EN model (Level 4 prediction of EN behavior.)	Level 1. What does student know.
		Yes, Sir.				
	But you're anticipating that the move is not going to be immediate? So you think you've actually got the jump on him, based on the fact that he doesn't know you're there and you have the chance to destroy him?		Q: Probe En model with Timing model to produce inference.	Still deepening on predicting threat behavior.	T2 EN model (Level 4 prediction.) T5 Timing (prediction)	Level 2 What will battlefield look like when; what are our options?
		That's correct.				

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
	What else are you seeing that reinforces this picture if anything? And what are you seeing that doesn't? What are you seeing that's maybe inconsistent with the picture you're painting?		Q: PRD EN model and Timing.	Instructor perceives student doesn't have as much time as he thinks he does. Student missing cue of T72s will report and mobilize Vietti's Farm tanks. Not a static AA.	T2 En Model (Level 3 Thinking EN.) T5 (Timing)	Level 1 Cues
		What am I seeing that's inconsistent with that picture?				
	If anything.					
		(Pause.)				
	Are you pretty happy with it? Are you pretty comfortable you've got a handle on what's going on here?		Q: Ask student to make self-evaluation.	Student is missing a cue, but doesn't see that when asked to reflect. So asked to reflect further.	T2 En Model (Level 3 Thinking EN.) (T5 Timing)	Level 1 Cues
		I do, Sir. I don't have any evidence that there is something else going on right now.				

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
CD 10:35	So there are no other interpretations of what Red could be trying to do here in your estimation?		Q: Probe overall EN model.	Student is missing a cue, but doesn't see that when asked to reflect. So asked to reflect further.	T2 En Model (Level 3 Thinking EN.) T5 (Timing)	Level 1 Cues
		I'm sure there are an infinite number of explanations, but I've got to choose one. This one matches as close to the situation as I can ascertain from the information I've got.				
	So is this a good situation or bad situation with respect to your estimate of what Red is? Are you happy with this? Does this cause you problems? Are you surprised by anything that you're hearing here?		Q: Ask student to make self-evaluation.	Student is missing a cue, but doesn't see that when asked to reflect. So asked to reflect further.	T2 En Model Level 3 (Thinking EN) T5 (Timing)	Level 1 Cues
		It looks like I'm up against maybe one Bde at this point. I still don't know where the others are. I've got the opportunity right now to mass on this Bde and surprise him and destroy the EN's armor VIC Vietti's farm.				
	You're estimating there's a Bde at Vietti's Farm?		Q: PRD EN model.	Student misses another cue. (Size of element.)	T2 EN Model (Level 2 Template)	Level 1 Cues
		Yes, Sir.				

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
CD 11:33	Based on?		Q: PRD EN model.		T2 EN Model (Level 2 Template)	Level 1 Cues
		Based on the number of vehicles there.				
	Which was?		Q: PRD EN model.		T2 EN Model (Level 2 Template)	Level 0 Basic technical information
		I'm reading 30-50 vehicles.				
	It was between 25 and 30 from the report by the LAV section leader. Which equates to a Bn.		S: Reminder of knowledge level information.	Error in EN element identification.	T2 EN Model (Level 2 Template)	Level 0 Basic technical information
		Roger, Sir. More like a Bn.				
	So are you saying you don't believe you've got a Bde here now. You've got a Bn?		Q: PRD EN model.		T2 EN Model (Level 2 Template)	Level 0 Basic technical information
		Right, Sir.				
	Does that change anything?		Q: Probe EN model.		T2 EN Model (Level 2 Template)	Level 0 Basic technical information
		At this point, no.				
	So the Bn is what?		Q: Probe EN model.		T2 EN Model (Level 2 Template)	Level 0 Basic technical information
		Probably a forward element of a larger unit.				
	What do we know about the way these guys like to operate from our experience in the last several weeks?		Q: Probe EN model.		T2 EN Model (Level 2 Template)	Level 0 Basic technical information
		(Pause.) You've got me there, Sir.				
	We understand that they prefer to lead with a Bn of tanks, right? Is this the Bn of tanks? I'm understanding that you are reading this as their advance element?		Q: Request CIN.		T2 EN Model (Level 2 Template)	Level 0 Basic technical information

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
		I am. If that is the case, I'm still pretty happy with the decision I've made, because once again, going back to my Cdr's intent--Destroy the EN armor and thus transition to the offense.				
Changes themes or viewpoint.	So you don't have a problem with ignoring your instructions to be in Viettiville by 0630 to be ready for the Div Cdr's counterattack?		Q: Probes model of Higher HQ intent.	Changes to HQ & mission theme. Script? Because Instructor was satisfied with student's EN model at this point? Or only wanted to hit one learning point in that theme now?	T1 HQ & mission	Level 2
		I do not. I'm not going to get there without taking care of this threat first.				
	Is getting to Viettiville still a concern of yours?		Q: Probes model of Higher HQ intent.	Q: PRD Big Pic.	T6 Big Pic	Level 2
		Sure. I think if I can get the jump on this guy here at Vietti's Farm, I may be able to get this over with and still get to Viettiville within a relatively short amount of time.				
	So your ideal situation would be to handle this situation and then continue with your instructions which are to get to Viettiville?		Q: PRD	Student has wrong picture.	T6 Big Pic	Level 2
		Yes, Sir.				
	And, the thinking there being what?		Q: PRD	Student has wrong picture.	T6 Big Pic	Level 3

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
		Thinking there being he doesn't know where I am, I do know where he is. I can mass VIC Balzer Hill, hopefully get this forces on line at the same time--Alpha, Bravo, and Charlie--mass fires on the EN VIC Vietti's Farm and the vehicles moving toward Balzer Hill, be done with it and press on through to Viettiville.				
	I get the idea of dealing with the problem here at Vietti's Farm pretty quickly, I'm asking the thought process now…you destroy this EN tank Bn presumably and then you're going to continue to move on to Viettiville with what in mind?		Q: Probe mission.		T6 Big Pic	Level 3
CD 14:35		With forming that AA with an unknown direction to continue that attack.				
	So you think the idea of AA in Viettiville is still viable at this point?		Q: PRD Big Pic.		T6 Big Pic	Level 3
		It is.				
	And your thought process there is?		Q: Rationalization for Big Pic.	Student is missing cues.	T6 Big Pic	Level 1
		I can see the direction you're leading me is that I haven't given any instructions for…				
	I'm just asking if you still want to get to Viettiville. What's the thought process there?		Q: Rationalization for Big Pic.	Student is missing cues.	T6 Big Pic	Level 1
		I keep giving you the same answer. I'm not going to get to Viettiville if I don't take care of these vehicles. If I keep pressing to Viettiville, my right flank is going to get hammered. He could move into my rear or deeper into the Div's area. Neither of those options I like.				
Cd 15:42	Why not?		Q: Rationalization for Big Pic.	Student is missing cues.	T6 Big Pic	Level 1

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
		I'm assuming that behind me are forces that are not nearly as capable of dealing with the forces at the laager site as I am.				
	That's absolutely true. We're in our rear area, so there's a lot of softer stuff back here. There's probably some artillery positions, some logistics positions...standard kind of rear area activities going on and you're better prepared to deal with this threat than anyone else. And you're worried that they might be threatening your own rear or your right flank. But it seems to me you're sort of describing the threat in terms of threats to you. Tell me a little bit about how you are reading how this effects the bigger picture--the situation that's starting to develop here with respect to Red.		S: Request for input from student.	Student is not getting it. Needs to display his thinking so that through his performance Instructor can see flaws in thinking.	T6 Big Pic	Level 1
		If I were to either press on to AA or make an end run around the woods--take the long route--I'm leaving a substantial force in the rear area.				
	Substantial enough that it is a threat to Div?				T6 Big Pic	Level 1
CD 16:48		Yes, Sir. If in fact this is the advance element of one of these maneuver Bdes, then the rear area of the Div could be in a lot of trouble.				
	So looking at the bigger picture, you understand that the Div Cdr's intent is what?				T1 HQ & Mission	Level 1
		Is to be in place at this AA for an offensive follow-on push.				
	So that is the task he gave you--be in the AA--but what did he describe as his intent of having you there?				T1 HQ & Mission	Level 1
		If I have written this down correctly, in order to destroy the EN's armor and transition into the offense.				

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
	To destroy the EN's armor, seize the initiative, and transition to the offense. And we know that the EN typically likes to lead with a Bn of tanks. The Div Cdr's overall concept is that he wants to launch a counterattack against these guys, blunt their offensive, seize the initiative, and transition to the attack.		Instructor models understanding of intent	Student's understanding is incomplete.	T1 HQ & Mission	Level 4
CD 17:46		Right.				
	Do you think that's going to happen out of Viettiville?				T7 Visualization	Level 3
		(Pause.) It looks like it's going to happen right here.				
	Is that what you're thinking?					
		Yes, Sir.				
	OK. Because it wasn't clear to me that was what you were thinking, but if it is, I think you're exactly right. In fact, Viettiville is obsolete at this point. The fact that it was AA is not important anymore. That was simply a control measure. What's really important to the Cdr is counterattacking, destroying the EN's armor and seizing the initiative and maybe it's happening here. Now, this wasn't our pick, but here's an opportunity, right?					
		Exactly.				
	So is this the Div counterattack?					
		Yes, Sir. It may as well start here. Like you're saying the AA is just a line on the map and at this point it has become irrelevant.				
CD 18:48	Let's talk a little bit about the timing of your situation. Why did you decide to make your decision when you did? What was the key piece of information that allowed you to make a decision when you made it?		Q: What cues?	Taken previous line of discussion as far as he could?	T5 Timing	Level 1

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
		I had a couple of elements of EN information. Hopefully, I knew where his lead trace was, and I saw a weakness that he had at the time and that was about enough that I needed to make my decision.				
	And the weakness was what?				T2 EN model	Level 1
		The fact that he was in a laager site which implies he's doing something logistical. He's doing preparations for something else.				
	So he's not necessarily combat ready--all of his forces. Anything else you see that reinforces that?		Q: Cues.		T2 EN model	Level 1
		The fact that he has so little reconnaissance forward. And if I don't do something in the next five minutes, we're going to be on parity as far as knowledge.				
	So you've got presumably about a five minute jump on this guy in terms of seizing the initiative and the element of surprise. And if you don't do anything between now and then you lose it.					
		Exactly.				
	Because number 1, he's exposed because he's doing logistical stuff rather than in a fighting mode. And number 2 he's blind because he doesn't have anything out there to see where you are so you've got the chance to get the jump on him.					
	What about this truck convoy coming down from Viettiville? Did that factor into your thinking at all? Why/Why not?		Q: Cues.		T2 EN Model	Level 1
		That did not factor into my thinking one bit. That left my consciousness really early on.				
	Not significant?					

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
		Could be significant. Right now the biggest threat is the armor. The best way for me to carry out my Cdr's intent is to focus on the armor. That's a nice lucrative target. It's probably not going to come my way once this fight starts going down, but I may be able to do some sort of pursuit.				
CD 20:51	So you're not really particularly interested in it? It's not a threat to you; it may be a lucrative target, but you're more interested in destroying the tanks. Does it tell you anything about the situation as you think about it?		Q: Cues.		T2 EN Model	Level 2
		(Pause.) It may be coming down to Vietti's Farm to logistically support this EN that's in the laager site.				
	Which tells you what?					
		Which tells me he's not planning on moving anywhere for a few hours.				
	So maybe that reinforces your initial assessment that you've got a chance to hit these guys cause they're in need of some kind of resupply. Does it tell you anything else about geography here?		Q: Cues.		T2 EN Model	Level 1
		About the geography?...Obviously the area to the NE is secure for the EN.				
	OK. Why is that significant?					
CD 21:49		If I'm in the rear area, there's a gap in our lines for the EN to get this far in our rear area.				
	So does it begin to appear that the situation is maybe a little bigger than just a tank Bn at Vietti's Farm?		Summary.	Need to reinforce student realization.	T2 EN Model	Level 1

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
		Yes, Sir. It appears that perhaps the thrust of this Bde is coming from the NE.				
	What does that say about Viettiville as AA?		Q: Cues.		T2 EN Model	Level 3
		EN is already in that AA.				
	Was that a part of your thinking? Did you internalize that or miss it altogether?					
		To be honest with you, the convoy dropped from my consciousness altogether.				
CD 22:50 Instructor switches to new viewpoint to summarize earlier info on use of FR assets and link it to Visualization.	Let's talk about your tactical plan a little bit. You've got three Co. on line: A, B, C. Delta is in reserve VIC Balzerton? They were moving up in trace of Alpha? And then you had your TOW section protecting your left flank and A,B,C up engaging the EN. So three tank CO on line engaging a tank Bn. Explain to me how you see this thing unfolding.			Switches when student "gets" the previous point.	T7 Visualization	Level 3
		Bravo and Charlie come up on top of the hill. Obviously, the jig is up. They're engaging. Alpha and the LAVs quickly take out the two T72s. We've got the drop on the EN at Vietti's Farm and the fact that we've got the weapon with the better PH/PK is going to carry the day.				
	So you think this thing is going to be over pretty quick?				T7 Visualization; T5 Timing	
		Yes, Sir.				
	Alright, then what happens?					
		From there, I'm issuing follow-on orders to establish a hasty defense in preparation for the rest of this Bde pouring down from Viettiville.				
	So you're not going to Viettiville anymore?					
		I'm not.				

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	Are you talking to anybody else?		Q: Probe T1.	?	T1 HQ & Mission	Level 1
		That was the next thought crossing my mind. Obviously I need to let someone know what's going on here.				
1549/ CD 24:19	OK					
		My report to higher is going to sound something like this. Spotted large force EN armor approximately 25-30 vehicles VIC Vietti's Farm. Appears to be in AA in prep for follow-on opns. Follow-on forces in the form of a motorized convoy are approaching from the NE. Am engaging the armor at Vietti's Farm. Will advise. Out.				
	What do you think Div's going to say?				T1 HQ & mission	Level 3
		They're probably going to ask for a lot more information than I've given them. But until I've got my forces up on Balzer Hill and I'm carrying out this attack on the EN laager site, that's less of a concern to me--keeping them informed than fighting this fight.				
CD 25:31	From Div's point of view, are they going to have a hard time with this report you're sending them?		Q: Consider situation from another's view.	Script?	T1 HQ & Mission	Level 3
From here, RPD notes only		They'll probably put together the same picture. Viettiville AA is no longer viable and the fight's going to start here at Balzer Hill.				
	Hmmm....... You're handling this rather well. Is this a normal situation? Or is it hard to explain, totally unexpected?					

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		This doesn't bother me. It's turning me on. I have an enemy weakness in front of me.				
	So you can get into a fight with your advantage without having to work for it...					
		Exactly				
	At the tactical level you like what you are seeing, but at the DIV level and what they are seeing and what they are trying to do, is this a good situation? Or is it causing problems? And does that influence the way you behave? Do you need to be looking at the bigger picture, past killing the tanks? And if so, how should that affect your behavior?		Look from another viewpoint.	Student may get locked into close fight focus.	T1 HQ & mission and T6 Big Pic	Level 3
		What's going to influence my behavior is where the other maneuver elements are [Red or Blue?] in relation to me...				
	Give me some possibilities here, some Contingencies?				T8 Con-tingencies	Level 3
		I may have to plug up this hole in the NE that Red is coming through				
	So he may be coming down from the NE, that's one. Did this tank Bn come from the NE? Does that matter?					
		No, it doesn't matter				
	OK, keep going. Other thoughts?					
		After the engagement is over?				
	Yes, let's assume that you have won. Talk through your actions and why.					

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
		Move the TOW to the NE, minor mods to my positions, but take him on the ground of my choosing.			T7 Visualization	Level 3
	So, you're putting your TOW further out to buy you time, is that right? To learn about these guys sooner?		Q: PRD	Student's stated use of assets.	T4 Assets	Level 3
		Yes, sir.				
	So could they be coming round here? (indicating track to the N)					
		I'd push the TOW up to the NE to block this avenue [didn't answer question]				
	Any other Contingencies?					
		Friendly or enemy?				
	Enemy. I'm trying to understand your reading of the enemy forces here…					
		Red is deeper than we imagined. Attack is coming from Viettiville, or from the N, that's all the info I have now.				
	It could be coming from here [indicates from the East]. Does that change anything?					
		If it's coming from the E, I'm still not in too disadvantageous a position, I'd move my forces a little.				
	OK. Let's take a different approach. Let's take a look at your tactical plan now.		New viewpoint--PreMortem analysis.	?	T4 Assets; T8 Con-tingencies	Level 3
	If your plan were to fail, why, how do you see this plan failing?					
		If it were to fail, maybe from an overwhelming force coming from the N, but I think I have enough forces there to deal with that.				
	So, if the enemy comes from the N, that causes you problems potentially?				T8 Con-tingencies	L3

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
		The TOW should be enough, they will buy me time, and D Co. will buy me time enough to deal with it.				
	Any other ways you see this failing? Not necessarily something that you did wrong…				T7 Visualization	L3
		If the LAV gave incomplete information and there is more out there than just the laager site, and there's a lot of dimounts on Balzer Hill.				
	So it could be that you have run into a much larger force than you can see, whether its infantry or mech inf, or tanks, or it's the rest of the Bde, not just a tank Bn. How do you deal with that? Is that plausible, am I being fair with that possibility?				T7 Visualization; T8 Con-tingencies	Level 3
		That's fair. What indirect fire assets do I have?				
	You don't have any, you're in an administrative move in the rear. You could try to get them… is that an option?					Level 0
		I could use artillery and air.				
	Do you think you'll get those without prior preparation with enough time to bring it into question?				T5 Timing	Level 2
		Yes. I've become the main fight. I'd get the assets. More likely air support, less likely arty, I'm outside their fan.				
	I'd suggest that you need more than that. This is the main fight. There's more than just this fight. You'll need more than that, this is just the beginning. You'll be shaping that for them. You have to be thinking about setting the stage and the inevitable actions that will follow this. This guy wouldn't send a tank Bn by itself, he's got something bigger in mind. It's not going to be over in the next half hour. If not you, someone will need the support and whatever you can do to support that, you need to be doing, right? Thoughts about setting the table for the DIV Cdr?			Student needs to see more cues.	T7 Visualization	Level 3

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
		Report to DIV…there's a big fight going down in front of me. Need indirect fire and air as soon as you can get it to me.				
	You destroyed the tank Bn, are you going into the defense to plug this thing?					
		I'd call DIV and ask for guidance, do you want me to press or hold?				
	DIV says you're going to have to wait while they check out this crazy story about tanks in the rear!					
		OK, so no support from DIV…				
	No, just that they need time to digest the information.					
		OK, I will go on the defense then.				
	OK, why? What's your thought process?					
		There's more out there, like you were saying…				
	Why do you think transitioning to the defense is the way to go versus pressing on?				T7 Visualization; T8 Con-tingencies	Level 3
		I don't know what's further to the East.				
	No terrain suggesting offensive options…?				T7 Visualization; T8 Con-tingencies	Level 1
		Sure.				
	What do you think about the level of uncertainty here? Is it a problem? Or is it clear?				T7 Visualization	Level 3
		It's somewhat uncertain. I have three options (AOA for Red). I'm discounting one, and I'm set up for the other two from the NE or East.				
	Right, but your assumption is that what you have is a Bn lead element and you don't know where the rest of the Bde is. You've identified one third of his combat power and you're assuming that there's more. That's a lot of uncertainty, right? How do you cope with that? With your plan, or another way?		Ask for student input.		T7 Visualization; T8 Con-tingencies	Level 3
		Sure. Circle the wagons, or deal with his most likely COA from the NE.				

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	OK, what are some ways that you can deal with uncertainty, tactically?					Level 0
		Shape the terrain, shape the situation...			T8 Con-tingencies	
	How?					
		Thrust to the NE, looks like a soft target right now.				
	OK, you could do that. What else? What about use of your reserve?					
		I can hold them back, wait for more information, or a weakness.				
	Right, but one way to deal with uncertainty is to hold a large reserve right?			Script?	T8 Con-tingencies	Level 0
		Sure.				
	The bigger the uncertainty, the bigger the reserve. Are you comfortable with committing 3/4 of your combat power to the plan? Are you comfortable with that?					
		Yes.				
	Why?					
		ABC are oriented to the NE, TOW to the N.				
	You're not concerned with getting your three tank Co's decisively engaged in a fight they can't get out of?				T7 Visualization	Level 3
		If they do that, I see myself as accomplishing my mission.				
	Let's drill back on what we're seeing from the enemy. Typically he leads with a Bn of tanks, what's missing here?			Backs up to clarify cues in EN model to support Visualization.	T2 EN model	Level 1
		The recon company.				
	Thoughts?					
		Maybe they have gone further south or West.				
	So the recon Co has already come through? You've been lucky and come up in between them?					
		Or they could be at the laager site.				
	Yes					
		I should be prepared for the other options.				

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
	How?					
		Well my TOW and D Co. are well positioned for the N/NW, and I don't see his recon Co. coming into the flanks of A,B,C as a problem, it wouldn't work out well for them.				
	Did you think about this in your plan?		Asks student for self-evaluation.		T4 Assets	Level 3
		No, but now we're laying out his table of organization, the piece that is missing was the recon.				
	What's one piece of information that you would like that would really help you clarify the situation?		Probe cues.			Level 1
		Where is Red's main thrust, where is the rest of his Bde?				
	What would that allow you to do?		Probe cues.			Level 2
		Choose advantageous ground to defend from or choose a route for a counter attack into Red's flank.				
	If you had to choose one or two concepts to describe your plan, principles, what would they be, and why?					Level 3
		Seize the initiative, and surfaces(?) and gaps.				
	Explain those a bit?					Level 3
		Red presented me with a weakness earlier than expected, it would be foolish not to take advantage.				
	So is tempo a big issue here?		Reinforce learning point.			Level 2
		Right. Five minutes and we would have been on parity.				
	Would you say the time factor was the single biggest factor in forcing your decision?					
		It almost always is.				
	What about surfaces and gaps?					
		He's presenting me with this weakness, I'd be foolish not to take it.				

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
	What about our surfaces and gaps? From our POV?					
		The enemy perceived a surface, I made it a nasty gap.				
	The point is that something happened in DIV defense that created a gap for these guys. We're now trying to close it down and maybe turn it around. You need to clarify the situation to DIV and help rectify it, set conditions for DIV to deal with the new situation. Looks to me like DIV is dealing with a situation that they weren't aware of, their existing assumptions are out of the window. You're in a position to avert a disaster and you are the guy with your finger in the dyke. You need to be thinking about it as a DIV level problem not just at the tactical level.			?	T7 Visualization	Level 4
		The friendly situation factored into it less than the fight in front of my face.				
	Why do you think that is?					
		Didn't have good SA of DIV forces, where they were.				
	If I'd given you a better idea of Blue, would that have changed it?					
		Yes, better realization that they had penetrated deep into the rear.				
	You didn't have a sense of that at the beginning? Was that a lack of information or just not putting it all together?					
		Didn't have enough information at the beginning.				
	Do you have any questions for me?					
		I needed more information at the front end, an idea of DIV front trace, emphasis that it was an administrative move...				
	What did you learn from this?					

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		Got to think about the bigger picture and not just the fight in front of me.				
	What else?					
		Look beyond the next half hour, what does that Red element mean with respect to the Red big picture... I had a good grasp of the initial situation and coming up with a good solution.				
	Yes you did it well, issued orders in about 45 seconds, clearly, except I misinterpreted A Co orders					
		I didn't use the proper terminology for orders, attack by fire.				
	Hand over to WolfPack...					
	I have two issues. Human factors. When was this occurring?					
		Early morning.				
	Pre-dawn. After doing what? You'd been on the road, right? You're a Bn Cdr with 800-1000 people moving down the road, at night... have you ever done that?				T4 Assets	Level 1
		Yes sir, probably everyone but the drivers are nodding off.				
	Nodding off, getting tunnel vision... when you issue your orders, you have to take that into account... What are your immediate thoughts on the order in that situation?				T4 Assets	Level 1
		Should probably include some sort of wake up message, painting more of the enemy situation. Looking back at my order, I assumed that everyone had the same enemy picture, which they didn't.				
	My order would look like this:Bn alert! Enemy tank Bn 2-3k to our right! Not even an ordinal direction, to our right! Get them in the ball game. What else about going into a fight at that time?				T4 Assets; T5 Timing	Level 4

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
		Got to have simple scheme of maneuver. From the Red perspective, life's pretty good, he's down too.				
	Yes, but the point I wanted was, you nailed it. It has to be simple. Also, you don't want to shoot up your own guys in a night fight. So take a look at your forces and where they are...		Reinforce learning point.		T4 Assets; T5 Timing	Level 3
		My dispersion of forces is wrong.				
	Yes, tight formations. Another factor might be the personalities of your commanders, and how they react. It might affect who you get to do what. It did me.					
	My second point is the meta problem. The SA of your SA. What do you think of the SA that you had? You know what I mean by SA?					
		Yes, Sir. Relatively low other than what's right in front of me. I was focused on the weakness.				
	One of the things I sometimes do is draw on the map what I can and can't see... the blue triangle is what I can see thru the Sgt in charge of the LAV section and also down the road we just came up. That's the SA of my SA. Me saying to myself what do I know.			Script?	T6 Big Pic	Level 4
	I want to talk about your report to the DIV Cdr. You said you had a large force, the DIV Cdr is wondering is that a large force for a Bn Cdr or for a DIV Cdr?					
		Yes, I think I added numbers after I realized what I had said.				
	Be specific. 20-25 T-72s 2-3 km from me. I've got to attack them, I'm in the attack, will advise.					
	Tell me about the fight after the fight, your hasty defense.					
		On the screen?				
	Sure draw it on the screen.					
		(Student is drawing...)				

Time/ Comments	Instructor to Student	Student to Instructor	Type of Interaction	Trigger	Theme	Scaffolding Level
	Explains what he thinks Red will do… passage of lines… so, you're going to have a bunch of bad guys coming. If you're the new (Red) Bn commander on the scene, and you see that there's been a fire fight (at VF), based on the terrain analysis, what would you do?			Script?	T7 Visualization	Level 3
		I'd dismount outside of gun range and probe.				
	I agree with the probing, but not the dismounts. What assets does the Bde Cdr have? I would use a maneuver defense… you want to win the counter-recon fight. Get artillery… (trails off discussion)					
	End of discussion					